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EXPERIMENTS *and* OBSERVATIONS,  
TO INVESTIGATE,  
BY CHEMICAL ANALYSIS,  
THE  
MEDICINAL PROPERTIES  
OF THE  
MINERAL WATERS  
OF  
SPA AND AIX-LA-CHAPPELLE,  
IN GERMANY;  
AND OF THE  
WATERS AND BOUE  
NEAR  
ST. AMAND, IN FRENCH FLANDERS.

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BY JOHN ASH, M.D.

Fellow of the Royal College of Physicians, of the Royal  
Society, and of the Society of Antiquaries.

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*Tales sunt Aquæ, qualis Terra per quam fluunt.*  
PLIN.

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—— BEhold ! the glooms disclose,  
I see the fountains in their infant beds ;  
Deep, deep I hear them labouring to get free :  
I see the leaning strata ——

—— The layers then  
Of mingled ores, of more retentive earths ;  
The gutter'd rocks, the mazy-running clefts,  
That, while the rising vapour they transmit,  
Restrain its motion and forbid its waste :  
I see the rocky siphons stretch'd immense,  
The mighty reservoirs of harden'd chalk  
Or stiff compacted clay, capacious form'd :  
O'erflowing thence, the congregated stores,  
The chrystal treasures of the liquid world,  
Through the stirr'd sands a bubbling passage  
burst,

And welling out, around the middle steep,  
Or from the bottom of the bosom'd hills  
In pure effusion flow.——  
But who their virtues can declare ? who pierce,  
With vision pure, into these secret stores  
Of health, and life, and joy ?

THOMSON.

## E R R A T A.

Page 49. line 1. for *in* read *is*.

53. 13. for *Tbirmal's* read *thermal*.

61. 10. for *lassene* read *lassone*.

114. 6. for *acid* read *air*.

116. last, dele *was*.

137. 11. dele *as well as aerated*.

255. 20. and, in some other pages, for *ferrugi-*  
*nous* read *ferrugineous*.

## P R E F A C E.

**W**HEN I first formed a design of going to Spa, Aix-la-Chapelle, and the adjoining places, so filled with mineral waters, in the summer of the year 1787, I proposed little more to myself than merely amusement, and to collect, if possible, some better information of the nature of those celebrated fountains, of which such different and imperfect accounts have been given to the public, by a great variety of writers upon them : for, having been engaged for near forty years in a very extensive range of medical practice, in a large and populous town, situated

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nearly in the central part of England, my attention had necessarily been directed to subjects of this kind ; and I had frequently directed the use of some of these mineral waters to my patients, on the authority of the best authors I could collect, who had written upon them.

The long-accustomed habits of constant employment in medical business, and a serious attention to every branch of medical knowledge for so great a length of time, soon induced me to enlarge my plan, and to provide myself with every necessary implement and apparatus to make a chemical analysis of these several waters on the spot, and to establish, if possible, a fixed standard of their several component parts, and deduce from thence some certain rules for the real medicinal  
uses



uses of so important a part of the *Materia Medica*.

The consideration, however, that so many men, and some of them of great character, had already laboured in the same field, without attaining to so desirable a purpose, would have checked a less ardent zeal to be of use to my brethren in the profession, as well as to mankind in general. So numerous have been the various writers upon Mineral Waters, that an author\* of no little eminence on these subjects informs us, that he has been assured by a gentleman of great reading, that upwards of a thousand treatises have been written on the subject of mineral waters only ; and the celebrity of the waters of Spa, in the bishoprick of

\* Dr. Falconer, of Bath.

Liege, in Germany, has, I think I can safely say, already excited the industry of at least an hundred of these writers ; and to add to so long a list of histories, essays, &c. already made, may be deemed superfluous, and absolutely unnecessary : and the very attempt must demand an apology, at least, to be made to the public, for obtruding upon it any additional burden on so trite a theme.

Great as the improvements are that have been made, by the very eminent men of these days, in every part of Europe, and in all branches of science, especially philosophical chemistry (although still in its infancy) a science the most conducive of any to useful discoveries in medicine, it may be deemed extraordinary, that the knowledge of the real composition of mineral waters,

waters, has not acquired equal advances to the other branches of natural knowledge.

But, however, sufficient improvements have been already made abundantly to establish these two facts; 1st. That many of the impregnations boasted to be found in some favoured mineral waters have been ideal; 2d. That the general impregnations in mineral waters are much fewer in number than most of the writers on these subjects have been willing to allow.

The adoption of these truths will tend to silence all those cavils, against any attempts to analyse by art different mineral waters, which are founded on these two reasons: 1st. A supposed impossibility of such an analysis being ever carried to the wished-for point of

B 3                      perfection;

perfection ; 2d. That the imperfections in the attempts will be apt to mislead mankind, by substituting false and uncertain theories in the room of long-established principles and facts.

The author of the following Essays would not wish to be thought desirous of lessening the merits of the writers upon the several mineral waters, which he has selected for his analysis : as he is ready to acknowledge that some useful discoveries, and very pertinent remarks and observations may be found in many of them. But whoever will take the trouble of reading through the numerous writers on the mineral waters of Spa only, will have sufficient reason to lament how very little the real knowledge of their component parts has been advanced, notwithstanding the great improvements held



held forth for the true investigation of them by modern chemistry.

All the writers upon these waters, who lived or wrote before these acquirements were obtained, are so far from giving any real information of their composition, that their deductions are derived from false principles, and founded in error : and many of the later authors seem either to be ignorant of these discoveries, or have not properly availed themselves of the benefit and advantages of them.

If real science and great knowledge are ever united with diffidence and candour, few only of the many writers upon mineral waters have any great claim to so blessed a combination : for there are hardly any other kind of writers who assume the same degree of confidence in their own abilities, or

who affect a higher or a more dictatorial style, even when they are writing from mere conjecture and speculation; for some of them never visited the fountains which they have chosen for the subjects of their disquisitions.

However simple in their composition many of the most useful and celebrated mineral waters shall be found on the chemical examination of them, good and experienced physicians will not readily adopt an opinion, which has been advanced by some of the best chemists and natural philosophers of these times, that artificial mineral waters may be prepared, by the bare union of these simple component parts in pure or distilled water, which shall be not only equal, but superior, in their salutary effects in the cure of diseases, to the original mineral

neral waters as they are prepared by nature.

I would not by any means be thought to derogate from the transcendant merits of two of these great writers, and who appear to be the most strenuous and sanguine advocates in advancing and supporting the opinion of the equality and superiority even of the artificial mineral waters over the original ones, when taken on the spot; and shall only beg leave to observe, that my own experience, during my residence at one of these celebrated mineral fountains, and a faithful attention to the effects of the artificial as well as the natural ones, compel me, though with reluctance, to express my dissent from such an opinion: and shall wish to strengthen my dissatisfaction, in opposition to such great authorities,

authorities, by observing how deficient the means of imitating these waters by art will be found; that it will appear in the course of this analysis, by real experiment, that some of the mineral springs at Spa do really contain a greater quantity of elastic permanent gas, in their water on the spot, than can be united with common water by any possible artificial means; and this abundant union of aerial acid may possibly be effected with the real mineral water by some extraordinary degrees of pressure in its passage through the earth, which can never be attained to by any artificial means on its surface.

In order to enable the reader of the following pages, who is not conversant in enquiries of this kind, the better to understand the several experiments hereafter



hereafter made on the different mineral waters, of which the analysis is attempted, through the improvements in modern chemistry, an introductory account will be prefixed to the analysis, of the several agents, which are of such consequence in the formation of mineral waters, and which can alone render them so highly salutary, and of such infinite use and importance in the cure of diseases, when every other means of relief from medicinal aid is and must necessarily be defective.

THE  
INTRODUCTION.

THE first and most important agent in the formation of mineral waters is the aerial acid, which is combined in several of the most celebrated mineral fountains in very large quantities, and which acts as the solvent of the several ingredients that enter into the composition of them, without the aid of a vitriolic or any other mineral acid.

That fixed, fixible, mephitic air, or by whatever term it is denominated, contains a real acid, *sui generis*, can be no longer doubted of, after the very satisfactory experiments that were made  
on

on this subject by the late excellent chemist Mr. Bewley, and by several other eminent authors since his time ; and which is called, by Sir Torbern Bergman of Sweden, by the general term The Aerial Acid.

The most common method of impregnating distilled or pure water with the aerial acid, is performed by collecting it, by the means of a proper apparatus, from a fermenting mixture of chalk and oil of vitriol.—It may be of some importance, for the clearer understanding the several experiments hereafter made for the analysis of the Spa waters in particular, to shew, that in the preparation and collecting the aerial acid in water, there will not be the smallest portion of the vitriolic acid contained in it rendered volatile, as might be supposed, by the act of effervescence,

vescence, and carried up with the aerial acid into the receiving vessel in the upper part of the apparatus.

The ingenious Mr. Hey has made a set of curious experiments (vide the Appendix of the first volume of Dr. Priestley's Experiments on Air) in order to discover, whether the acidulous taste, discovered in water which is impregnated with this kind of air, was owing to the presence of any mineral acid in it, or only to the union of the aerial acid which it had absorbed from the vapour of the effervescing substances.

From these experiments it appears, that if a tea-spoonful of the syrup of violets shall be mixed with an ounce of distilled water, saturated with aerial acid, procured from chalk effervescing with the vitriolic acid, no change whatever, either

either on its first mixture, or after it had stood twenty-four hours, was discovered in the colour of the syrup of violets, except what was occasioned by its dilution in an ounce of the water thus prepared : neither could he discover any difference in the colour of the syrup, whether it was mixed with plain distilled water, or with an ounce of distilled water saturated with the aerial acid ; but in one ounce of the acidulated water, taken from a pint of it, into which one drop only of the oil of vitriol had been put, on adding a tea-spoonful of the syrup of violets a manifest change of colour was seen in the mixture, from what had appeared before the vitriolic acid was added to it. Yet Bergman, amongst other experiments to prove fixed air to be an acid, tells us, that it changes

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the blue juice of turnsole into red; and Mr. Hey confirmed it by experiment here; and moreover informs us, that when water is tinged blue with the juice of turnsole, and afterwards changed to red by the aerial acid, on exposure again to the common atmospheric air, it will resume again its blue colour.—This celebrated Swedish chemist, upon this subject, relates, that syrup of violets, and many other blue vegetable juices, will not be changed to a red colour by the aerial acid; yet the tincture of turnsole, of all known tinctures the most obsequious to acids, insomuch that the slightest vestiges of acidity, which are not to be discovered by any other methods of trial, are by this tincture readily detected.—It may be necessary, for the instruction of the reader who has not studied



studied much this part of philosophical chemistry, to observe, once for all, that in reading different authors who treat on these subjects, it behoves him to distinguish particularly between what is here called fixed air, and common atmospherical air; for all authors who wrote before the years 1767 or 1768, describe the effects of air in giving a quick, lively taste to water, and indeed to many other natural productions: they never supposed that there was really any difference between common atmospherical air and this peculiar kind of air, which is the subject of our present enquiry; they observed only, in general, that some certain substances, on mixing them together, as well as some processes in nature, generate air, and others absorb it; on a bare supposition, that the diminution of

air was only a separation of it from the common mass in the substance, without any change happening in the properties of what remained behind in the mass.

This discovery is due to the philosophical sagacity of Dr. Priestley; who residing about that time at Leeds, in the neighbourhood of a brewery (which circumstance led him to pay particular attention to the history of air in general, and the generation or separation of it from different bodies) and happening at the same time to read Dr. Brownrig's paper on Spa water, availed himself of the happy opportunity of the adjoining brewery to collect this air, by placing shallow vessels filled with water within the region of the fixed air, floating on the surface of the fermenting vessels; and  
leaving

leaving them there all night, he generally found the next morning, that the water had acquired a very sensible and pleasant impregnation ; and expressing peculiar satisfaction on first tasting this water, breaks out in the enthusiasm of the true ardour of genius, “ that this  
 “ water was the first of its kind that  
 “ had ever been tasted by man.”

To establish the fact, that fixed air is a real and true acid, it will not be necessary, in such a treatise as this, to give a minute detail of the various experiments that have been made by the first chemists, by which this doctrine is confirmed, that it is really possessed of all the properties that belong to acids in general, and that it is endowed with most of those characteristic marks which are peculiar to acids, and which distinguish them from all other

C substances

substances in nature ; and fixed air must therefore either be a real acid, or we are not in possession of any certain criterions of acids.

Fixed air is also capable of being united with other substances, as well as water, solid as well as fluid bodies ; and such substances, when saturated with fixed air, will in the following essays be said to be *aerated*, to indicate that they contain that acid which is ever present in common air, in the same manner as such salts as are saturated with a vitriolic acid, are denominated by the term *vitriolated*, joined to the name of the base with which that acid is united.

From these experiments, fully ascertained, we may learn the following facts, of the perfect agreement and similitude in operation of fixed air with  
all

all other acids. It excites a distinct sensation on the organ of taste; it changes the blue tincture of turnsole to red; it attacks the fixed alkalies, renders them mild and chrySTALLIZABLE; the volatile alkalies it renders more fixed, less pungent, and chrySTALLIZES them; pure lime, when only saturated with it, becomes less acrimonious and indissoluble; give a superabundant quantity of fixed air to pure lime, and it becomes again soluble; it acts in the same manner on terra ponderosa. With magnesia it forms a chrySTALLIZABLE neutral earthy salt; with iron, zinc, and manganese, it forms salts; dissolve these salts in water, and it will redden the blue tincture of turnsole. It exerts elective attractions, both double and simple; it forms a precipitate with

all substances dissolved in pure alkalis; it is volatile in a great degree, and very readily, although part of it will remain tenaciously united with boiling water, but that will be readily detached by congelation, in a similar manner as the weaker acids are concentrated by a similar degree of cold; and, finally, it eagerly attaches itself to all phlogisticated bodies.

It would be a tedious and unprofitable task to investigate the ground of the theories contained in the immense variety, which in the earlier days of chemistry appeared on the subject of the nature and properties of certain mineral waters; the visions of alchemy, and the jargon of the school of Paracelsus, appear in many of the earlier researches, which took place before chemistry began to deserve the name  
of

of a science ; and, till very lately, error and contradiction marked the generality of hypotheses which speculative ingenuity produced on a subject so remarkably fertile.

Vitriolic acid, in its common and volatile state, a peculiar and unknown acid ; the spiritus mundi of Hoffman, an occult spirit ; an ens primum of iron, and a great variety of agents equally unsupported by reality ; have been brought forward, as the principles on which the properties of waters, that were called acidulous, depend.

Though something may be due to those former observers, who, with Dr. Springfield, threw out similar opinions of forming a history of mineral waters, by an appeal to experiments which refuted the former ill-grounded theories ; yet, to establish an approxi-



mation to truth, upon such a system of experiments, seems to belong almost exclusively to Venel.

The enquiries of this chemist, (which, as he knew little of the real distinctions between common and that which is now called fixed air, were not carried to perfection) appear to have directed the attention of the philosophers on the Continent to researches on that substance, which was undoubtedly aerial, and the knowledge of which could alone explain the properties of these acidulous waters. A succession of well-directed experiments, from the time of Dr. Black's discoveries to those of the present day, has cleared up all the difficulties in regard to the peculiar properties of gaseous springs; that substance, which so long eluded all the keenness of research, is now in our hands,

hands, to combine or separate at pleasure: and the discoveries of Bergman, Bewley, &c. which have demonstrated the acid nature of fixed air, have at last produced one uniform and simple system, and perhaps have left us little more to learn, with regard to its properties, as an agent in the formation of mineral waters.

Many difficulties occurred in the earlier investigations of mineral waters, from the appearance of earths and metals evidently insoluble in water, being found combined with the aqueous fluid, and in such a state as did not correspond to any combinations of acids or alkalies; though both, but more especially the vitriolic acid, furnished, as was supposed, by the decomposition of pyrites, were called to the assistance of the framers of hypotheses.

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In proportion as the properties of fixed air became more known, the ambiguity belonging to this part of the subject disappeared. The honourable Mr. Cavendish, Bergman, and many others, nearly at the same time observed, that although aerated lime became insoluble in water, from its union with some portions of fixed air, an excess of acid enabled water to take it up with great facility. This effect, indeed, might have been expected from the discovery of the truly acid nature of fixed air : and in the same manner *terra ponderosa* refuses to unite with distilled water ; yet water saturated with fixed air will dissolve it, though not with the same facility as it does lime.

The application of these facts to *magnesia* had been already made by Bergman, and a similarity of effect had sufficiently

sufficiently been proved. Mr. Butin., of Geneva, who did not know what Bergman had written on the subject, has still thrown further light upon it, by a train of curious experiments. We find these two chemists agree together in stating the quantity of magnesia, precipitated in the common way, from a solution of Epsom salt taken up by an ounce of water, saturated with fixed air, at about thirteen grains; while distilled water can only take up one grain and a half to an ounce.

Following the path chalked out by Mr. Cavendish in his experiments on Rathbone Place water, Mr. Lane made some researches into the mode of union between water and iron, and traced it to the agency of the same substance: the

the facts which have since confirmed this opinion, applied to other mineral waters, are too well known to need a relation of them.

The volatile alkali, which, though not very frequently occurring in mineral waters, is sometimes present in them in a very perceptible manner, and probably united when disengaged, as alkaline gas. Some waters analyzed by Mr. Cavendish, as also some by Malouin, seemed to contain a considerable quantity. The putrefaction of animal or vegetable matters has been supposed the only mode by which mineral waters could be combined with the volatile alkali; but the discoveries of later times will enable us considerably to enlarge our views on the subject of the genesis of this substance. The investigations of Lord Dundo-

nald,

nald, and the French, have detected it in very great quantities in the mineral kingdom, as making a part of pit-coal, &c. The ambiguity of the origin of certain species of pit-coal, may render the mode in which volatile alkali is found in such substances rather suspicious ; but experiments of a modern date shew, that the general ideas of the nature of volatile alkali have been too much confined, and point out a variety of circumstances, under which, combinations producing this alkali may be effected.

The decomposition of volatile alkali having been accomplished by Monsieur Berthollet, it remained that trials should be made by different combinations, to form it from its constituent parts.

Dr. Priestley had some time ago observed,

served, that from the contact of iron and nitrous air, as well as from dissolving iron in a dilute solution of copper in nitrous acid, the production of volatile alkali discovered itself by the smell. Mr. Kirwan found, that when hepatic air was mixed over mercury with nitrous gas, a strong smell of volatile alkali took place.

Our knowledge of this subject has been lately enlarged by Mr. Hauffmann; who, by treating certain phlogisticated precipitates of iron with nitrous air, has by that method also procured a volatile alkali.

The facts point out sources from whence the volatile alkali may be supposed to arise, different from what has been generally imagined, and shew that its introduction into mineral waters may be effected by other means

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than those to which it hath hitherto been confined; that is, the decomposition of animal or vegetable matter.

The term *Phlogiston* was first introduced into chemistry by Becher, who was born at Spires, in Germany, in the year 1625; and, from being at first professor of medicine, became physician to the Elector of Mentz, and at length first physician to the Elector of Bavaria. In this situation he was persecuted by all those that were envious of his signal abilities and great eminence; and, to avoid their fury, was compelled to leave the country, and passed into England, and came to London; where his fame had arrived long before he appeared in person, and where he died in 1685. This great chemist and metallurgist soon perceived,

ed, that the doctrine of inflammability was falsely confined to sulphur, which, properly so called, did not exist in animal and vegetable substances, and which were all inflammable; and maintained, that inflammability resided in something that was common to real sulphur, and all animals and vegetables, as well as various other kinds of bodies: this substance he supposed to be of a nature which was then called *dry*, perhaps an earth he thought, and called it *Phlogiston*.

G. E. Stahl, who was a disciple and admirer of Becher, has published a distinct treatise on the presence and influence of phlogiston in several bodies: his opinion was, that this was the principle of pure fire, or the matter of fire resident in all combustible bodies, and he styles it the *inflammable principle*,

*ple*, to distinguish it from open fire, or fire in action.

The simple and noble idea M. Stahl formed of phlogiston was, that its properties were different from those which real fire presents when in open action, and presents to us its heat and light, the clear and distinct marks of the presence of actual fire and combustion. All inflammable bodies contain real fire combined in their formation, and which is the principle, in his idea, of their inflammability; but he regarded the phlogistic principle to be identically the same in all substances, and which contained or concealed it in them, of whatever nature the bodies were, or under whatever difference of forms they were represented to us by our senses; it is sufficient to render them combustible that they contain his

D phlogistic

phlogistic principle, (such being the language of chemistry in his days) in greater abundance. Thus sulphur, coals, metals, oils, phosphori, &c. owe all their properties to the presence of this principle; and that the difference of its appearance in these several bodies when in open action, arises from the different combinations with which it is united, but the phlogistic principle ever continues the same, and never ceases to exist till it quits these several combinations, and passes into the state of open fire. To explain the properties of fixed fire, or of fire in its phlogistic state, M. Stahl compares, in his own treatise, those bodies, in which it is supposed to be contained in different degrees with respect to quantity, with those into the composition of which it does not appear to enter: the first, he  
 says,

says, have generally some degree of colour, smell, fusibility, volatility, and combustibility ; while the latter bodies are in general without colour or smell, are more or less fixed, are not fusible, and incombustible ; and all bodies that are manifestly phlogisticated, by this doctrine must lose the greater part of their general properties when they are deprived of this principle, and will recover them again on restoring to them their phlogiston.

Thus the general doctrine of phlogiston, first introduced by Becher, became improved, and rendered much more extensive, by the natural sagacity and wonderful abilities of the celebrated Stahl ; and he raised on its first foundations so beautiful a structure of curious and important discoveries, in which all the phænomena of chemis-

try are placed in so strong a point of view, that new and strong lights are thrown upon the darker and more intricate parts of it, and all the branches of philosophical as well as medical chemistry are so happily illustrated by it, that such a regular, uniform, and well-connected plan of explaining all the processes both of nature and art, has been generally adopted in most parts of Europe for more than fifty years past.

Faults, however, have been found in the elegance of this system, and objections will still continue to be made to the harmony of the composition; and it must be confessed, that at first view the doctrine, however general it ought to be, is founded on the supposition, that inflammable bodies do really contain some substance, that is  
not

not to be found in bodies that are really not so; but modern chemistry seems to be in possession of proofs, that the supposed basis of the system has real foundation in nature.

The real difficulty of exhibiting the substance of phlogiston alone, formed another objection; in order to obviate the difficulties which will be cleared up hereafter, the later chemists, instead of explaining the cause, supposed the difficulty arose from the active nature of the principle, as it was called, which, on quitting any one body, immediately united itself to another; and, under these objections, which are of no great weight in reality, these chemists acquiesced the more readily, without resolving them, as they were totally at a loss how to substitute another mode of explaining the natural phænomena in



so ready a manner as under the auspices of this accommodating theory. Another objection was drawn from finding that metallic bodies did really acquire additional weight by being deprived of their phlogiston, which, by this system, was supposed to be a real part of their substance; but this objection is happily and by good luck done away, without any real design of explaining the cause of it.—The increase of weight acquired by metals in their calciform state, after the loss of their phlogiston, is to be ascribed to a real absorption of air, and not to be any additional increase of weight from either fire itself, or of sulphur in any form. And the truth of this fact is fully established by a celebrated French chemist, who is nevertheless a strong opponent of the phlogistic theory; for

Mr. Lavoisier has proved by real experiment, that the additional weight which metals acquire by calcination is perfectly correspondent to the quantity of air which they absorb.

The difference in opinion which at present subsists between the English and some of the first French chemists, on the subject of our present enquiry, may, perhaps, give rise to much future altercation; yet, if the dispute is conducted with that temperance and candour which becomes men of real science, it may ultimately fix the doctrine on a firmer foundation than the simplicity of the works of nature may render plausible, or the conveniency of readily explaining her operations would tempt mankind to adopt.

Although the reality of such a substance as phlogiston existing in nature

may seem at first view to have very little connection with the history of mineral waters, yet it may be found of such importance hereafter, in an account of the composition of some of them, as to render a short and familiar narrative of the origin of this dissention not improper, for the information of such readers of it as are but little conversant with subjects of so abstruse a nature.

Mr. Lavoisier first published the opinion, that common atmospherical air really consisted of two distinct fluids; one of which was fit and necessary for the respiration of animals, and the support of fire or combustion, and which therefore he styles, in his different publications, vital or pure air; the other remaining and greater part of the circumambient fluid is unfit  
for

for either of these purposes, and which he calls foul or mephitic air : and he has ascertained also, that the proportion of pure air in common air, was to the foul or mephitic air, in the ratio of one to four.—The discovery of pure air, as it is here called, is justly due to Dr. Priestley, and which in his works he calls dephlogisticated air ; which, in the proper sense of the term, will signify air depurated of the foul or phlogisticated part of it ; yet, in the philosophical idea of it, it means pure air.—The next step Mr. Lavoisier takes, and in this also he was anticipated by Dr. Crawford, is to prove, that pure air contains more fire than any other kind of air, and that, during combustion, it gives out this fire in the form of light and heat.

Having

Having thus established his first principle, he proceeds to form a new system ; and for this purpose advances an hypothesis which is entirely the reverse of the old doctrine. The ancient opinion was, that all inflammable bodies contained a peculiar substance which does not exist in bodies that are not inflammable : on rejecting this opinion, he defines inflammable bodies to be such bodies as have a strong affinity with pure air ; and, in order to fix this first stone of his edifice, he proceeds to prove by real experiment, that the remains of all bodies after combustion, and of metallic bodies after calcination, do really contain a certain substance which they did not possess before these processes. Now, this being an effect, may possibly be deemed foreign from the causes of combustion or calcination.

calcination of metals ; but from these appearances after combustion and calcination, he first proposes his doubts, whether, in the simplicity of the operations of nature, the supposition of such substance as the chemists call phlogiston was not entirely unnecessary.— It may be asked, whether, in the combustion of inflammable bodies, and in calcination of metals, the effects of both are not to be estimated by what they part with, and not from what they acquire, either after or during the operation ? If some of the metals are calcined in vacuo, the particular substance they part with will be found to be inflammable air ; should any pure air remain by accident in the vessel, water will be formed by the union of them ; and, should any part of the metals be in a calciform state before it

was

was submitted to the operation, (which may be the case should the metal be iron, but which cannot be supposed frequently to happen) water also, or fixed air, will be formed, which did not originally exist in the body, and which will be absorbed by the calces in exact proportion to the increase of their weights.

The objection before stated, of the defect of exhibiting the substance of phlogiston singly, began annually to receive further illustrations from the publications of Dr. Priestley, till, from these experiments, and many other suggestions by ingenious men, it was inferred, that inflammable air really existed in bodies, before its extrication from them in a concrete form, till it manifestly appeared, that inflammable air in its fixed state was the very substance



stance which the ancient chemists called phlogiston, and that it was really possessed of every character and property which they attributed to this occult quality, as its opponents then and since their times have called it: and it ought no longer to be considered as a mere hypothesis; but it may be clearly demonstrated to exist in its aerial form, with as many distinct properties, and to be as true and absolute in the mode and form of its existence, as any other species of air whatever.

The theory of chemistry, which may be called philosophical chemistry, is much indebted to the industry and abilities of some of the most celebrated French chemists, as well as to the labours and sagacity of Dr. Priestley in this country; and great obligations are due

due to both, and particularly to Mr. Lavoisier, for our advances in the knowledge of the nature and composition of acids.

That pure as well as common air suffers great diminution in their quantity, on uniting either of them with nitrous air, and also during the combustion of some particular bodies, we owe to Dr. Priestley ; but the singular connections and relations of pure air with the different acids resulting from the union of them, and many other improvements in this part of chemistry, were first obtained by Mr. Lavoisier ; Mr. Kirwan had indeed, in different papers in the Philosophical Transactions, taught the union of pure air with the phlogistic principle, in the formation of fixed air, and a variety of results from thence in different modifications

difications of it; but it is from the French chemists that we learn, that all the acids consist of two principles, one of which is peculiar to each particular acid, and this they esteem to be a simple undecomposable substance; and the other, pure air, reduced into its smallest volume, which signifies it to be deprived of most part of its specific heat, and this state of it is called its concrete state.

The first of these principles they style, the basis of the acid, and the latter to be pure air, and which, in their modern nomenclature, is called the oxygenous principle. Thus the vitriolic acid consists, in their opinion, of sulphur as its base, and pure air in a concrete state.

This doctrine of the composition of acids is admitted by the defenders of phlogiston

phlogiston, except that some of the French chemists, who are also phlogistonians, unite phlogiston with the different bases of the acids, and which they say they will lose on uniting with the pure air; and it must be left to them to prove how this union can take place without forming a new compound, in opposition to Mr. Lavoisier's elementary nature of these bases.

In the opinion of some writers, such a union of pure air with phlogiston, must either form the compound of water, as the experiments of Mr. Cavendish are intended to shew, or fixed air, according to the sentiments of other authors. Mr. Kirwan is of opinion, that the only circumstance by which water has been clearly proved to be the result of the union of inflammable air  
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and pure or dephlogisticated air, in that in which one or both of these airs were exposed to a red heat; and moreover it is apparent, that in lower degrees of heat fixed air will be the product of the union of the two airs.—The idea of the vitriolic acid, whose basis is sulphur, of Mr. Lavoisier, is opposed by one of the most intelligent of the English chemists, on these grounds—that the radical principle of this salt, abstracted from water, which it always contains, by uniting with phlogiston, forms sulphur as a compound; and that with fixed air it becomes common fixed vitriolic acid; but with both pure air and fixed air, in different proportions, it forms volatile vitriolic acid, of different degrees of volatility.

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The nitrous acid is involved in much greater obscurity, in relation to its component parts, as well as in the variety of its effects; but in such an introduction, that is prefixed to an analysis of some mineral waters, it will be sufficient to say, that the constituent principles of nitrous acid are fixed and inflammable airs, with both phlogisticated and dephlogisticated airs, with different proportions of these principles, as the acid proves red, yellow, green, or blue, with different degrees in the intensities of the colours, or pale and colourless, united with the peculiar acid as its basis.

Common *marine acid* is said to consist of a peculiar base united to phlogiston, with a certain proportion of fixed air, to both of which the basis seems to have a strong affinity; for, in

proportion as it is deprived of its phlogiston, it acquires a stronger affinity to fixed air; and the acid resulting from the union of the dephlogisticated basis with an excess of fixed air, is called the dephlogisticated marine acid.

The properties of this acid, since the discoveries of Monsieur Berthollet, seem alone, in Mr. Kirwan's opinion, to afford any plausible ground for the antiphlogisticated theory. According to this theory, the common marine acid consists of a peculiar base, united to a small proportion of pure air, or the oxygenous principle; and the dephlogisticated marine acid differs from the common one only in containing an excess of this principle.

The common marine acid destroys vegetable colours, by depriving the

colouring matter of its phlogiston, and saturating it with fixed air; and the addition of an alkali will not restore the colour, as alkalies cannot restore the phlogiston.

*Aqua regia* is formed by mixing equal quantities in bulk of common marine acid, with strong colourless nitrous acid; and in this composition, the marine acid will deacidify in great measure the nitrous one, while the nitrous acid dephlogisticates the marine; or, which is the same thing, the marine acid will take up great part of the fixed air of the nitrous, while the nitrous acid will take up the phlogiston of the marine; and hence part of the nitrous acid is converted into nitrous air, which unites to the undecomposed part of the nitrous acid, and forms a  
phlo-



phlogisticated nitrous acid; and hence aqua regia becomes of a red colour.

The three principal mineral acids can alone demand any particular attention on this occasion; hardly any other acid, except the aerial acid, already explained, can be of sufficient importance to require a particular consideration.

There is no question that has engaged the attention of philosophers and naturalists more earnestly, than by what means the different simple Thir-  
mal's baths and springs, which are found in many parts of the world, of such different latitudes and temperatures, and the different impregnations that are found in some of them, together with the several causes of the different degrees of heat which constitutes them either simple, tepid, or hot

baths, or warm medicated waters; and there is no question on which the best of these writers, and the best informed chemists, have given less satisfaction.

It unfortunately has happened, that those arguments which have been brought forward to explain by what means warm medicinal springs have acquired their several degrees of heat, will not apply with equal force when they are directed to solve the difficulty, how simple unimpregnated warm baths have acquired their several degrees of warmth.

That *dernier ressort*, to conceal our ignorance upon every question that arises of difficulty, in the explanation of the phænomena within the upper part of the earth's surface — the central emanation from a vast mass of fire or heat placed in the center of the earth —

earth—although received in a favourable light by many great philosophers of these times, cannot possibly be admitted in our present case; as it must equally affect all adjoining springs of common water in the same parts, which we find to be by no means the fact; and perhaps the supposition itself may prove groundless, and unnecessary to explain other natural appearances.

Some further weight may, perhaps, be allowed to subterranean local heat, occasioned by effervescent substances, in producing a degree of heat, that may lie extrinsic in the bowels of the earth, from the passage of the water percolated through different strata at some remote distances, yet within the sphere of the activity of these heating substances.

In volcanic countries, the different springs, both simple and mineral, may be supposed to receive very uncertain degrees of heat from the different states of the neighbouring volcanos : but the volcano itself may be produced from similar substances acting on each other, in the conversion of absolute into sensible heat, till they break out into actual fire, and form eruptions from the mountains. The supposition of partial subterraneous fires, adjoining to the currents of the fountains within the earth, appears without the least real grounds of support. If the term, *subterraneous fire*, has any specific meaning, it must denote the combustion of accumulated bodies of inflammable substances : another difficulty will arise from the infinite consumption of the combustibles, and a cessation by degrees

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of all possible warmth being obtained from thence; whereas the fountains have preserved the same degree of heat, and possibly without the least diminution of it, through unnumbered centuries.

I shall leave the reader to embrace whichever of these reasons shall appear most plausible to him; perhaps he may find it most reconcilable to common-sense to suppose, that these different degrees of partial heat in distinct and separate fountains, that are found in several parts of the world, may arise from large bodies of pyrites, or other mixed substances capable of exciting great degrees of heat when moistened with water; and if they are in immense bodies, they may lie remote from the course of the fountain, and beneath the detection of human inquiries,

inquiries, and do not communicate any impregnations of themselves to the waters through their great distance from them.

Notwithstanding the attention of philosophers has been for a long time turned to the investigation of the nature and origin of the aerial acid, as well as the reality and properties of phlogiston; and experiments have been multiplied throughout all Europe, directed to both these points; the opinions of the chemical world are still unsettled on these subjects; and in this respect chemistry is, as it was before said to be, in its infancy. Passing over the speculations, which the still earlier days of chemical knowledge produced in regard to aerial fluids, the two theories which, at this period, divide the general

neral body of chemists, deserve some notice on a subject like the present.

The superior seducing simplicity of the antiphlogistic doctrine appears, on examination, when applied to the matters before us, as well as in general, delusive and unsatisfactory, since, by the introduction of an elementary substance, under the title of *Matiere Charbonneuse*, to serve as the basis of fixed air, the list of chemical elements is unnecessarily increased, and, in fact, two inflammable principles, instead of one, are acknowledged in certain bodies.

It is said, that in the operations with charcoal, plumbago, and the various substances to which *Matiere Charbonneuse* is attributed, that the fixed air, which results, has no connection with the inflammable air or phlogiston, but  
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that it is a combination of the pure air with the proper base of mephitic acid : but it has rested on the adherents to the French hypothesis to demonstrate, why *Matiere Charbonneuse* is not to be considered as a mere verbal distinction, since from the evidence of facts it differs not from what those of the other opinion call phlogiston. How is it proved, that charcoal is the only proper basis of fixed air, and a peculiar matter, when it has been already proved, that the effects resulting from the union of pure air and charcoal are produced equally from that fluid and metals? Although it has been said, that *charbon* exists in metals, the idea has been always hypothetical : if the presence of plumbago in iron may prove a valid objection, the production of the same effect with zinc, brass, lead, and  
other



other metals, is still sufficient to demonstrate the fact. If *charbon* does exist in metals, as we know what alone can be procured from them in vacuo, inflammable gas, then that air, and coaly matter, come at last to the same thing.

The identity of *charbon*, and the inflammable air, is further evinced by the experiments of Monsieur de Laffene and Pelletier, who found that zinc, heated with caustic alkali, after disengaging a little inflammable air, leaves the alkali combined with aerial acid. And Monsieur Metherie has made a beautiful set of experiments, by which it appears, that all those metals which will detonate with nitre, leave after deflagration the alkali effervescent.

If then, as it appears from the argument of fact, that *Matiere Cbarbonneuse* simply answers to the idea of phlogiston,

ton, the substitution of which has precisely the same effects ; it can scarcely be deemed accurate or philosophical, to make a distinction between them, which uselessly enlarges the number of simple substances ; and the experiments which have been made on combinations producing aerial acid, still further evince the inutility of the substitution of *Matiere Charbonneuse* in the chemical nomenclature.

Although, from the intricacy and subtlety of the subject, and the imperfection still remaining in our knowledge of chemical agents, hypothesis is so often inapplicable, and even experiment so indecisive ; the weight of positive fact would seem to be in favour of the opinion so ably defended by Mr. Kirwan, although adopted by few at present on the continent, Mr. Sennebier,

Sennebier, and some others, excepted.

Analysis and synthesis seem to have approximated, as near as the matter would allow, to a proof of the composition of fixed air from the inflammable and pure gases. Experiments collected from the great number of them, which the industry of chemists has lately multiplied to an enormous bulk, are singularly repugnant to Mr. Lavoisier's theory, and throw real light on the nature of fixed air.

If brass, zinc, &c. as metals, are simple substances, and treated with pure air, or substances containing pure air, only receive the oxygenous principle, it is inexplicable how, under such circumstances, they again do not yield the elementary substance; they could only on that supposition receive,  
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but give out very large quantities of aerial acid ; a fact more remarkably exemplified in the amalgamation of mercury and lead in pure air.

Metals and charcoal treated together by heat as elementary bodies, should furnish nothing ; but it is well known, that large quantities of inflammable air are produced ; and when pure air is present, the aerial acid is always the result.

In the experiments made on brass, zinc, &c. with pure air, our present knowledge is sufficient to give us positive information, that they furnish nothing but inflammable air : and the same has been shewn by Mr. Kirwan, with amalgamas treated by a distilling heat.

The synthesis of the fixed air, in these and similar forms of exhibiting it, seems  
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to be obvious, and not to be explained away by the antiphlogistic doctrine; if the experiments with charcoal should wear any ambiguity, from the French hypothesis relative to that substance, an appeal to fact is to be made, as experiments are recorded in which charcoal, exposed in vacuo to violent heat, was found to disappear altogether, and, at the same time, nothing was produced but inflammable air.

Many of the facts related by Hermstadt, de Lussone, Pelletier, &c. afford the strongest evidence in favour of this idea of the nature of fixed air, and are inexplicable on Mr. Lavoisier's principles.

A variety of experiments, exhibiting decompositions of fixed air, seem to shew that the analysis answers to the ideas of the synthesis: as those of Mr.

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Monge with the electrical spark ; those in which the calces of metals, after having absorbed fixed air, give out pure air, and the metals are revived ; the phænomena of certain calces, which, according to the degree of heat, give out fixed or pure air ; the general nature, and the appearances of the metals occurring in the earth in a calceform state, without suffering any change by art ; and lastly, Mr. Hermstadt's experiments with manganese, which seem to make directly in favour of such a combination.

It is sufficiently obvious why the immediate application of pure to inflammable air, does not in all cases generate mephitic acid ; for when the two airs contain their full proportion of heat, the union cannot take place till the absolute heat is converted into sensible,

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ble, or fet at liberty :—for it would appear by some experiments lately made, that even in this state a reciprocal action may take place in peculiar circumstances, although the experiment of Dr. Priestley, with pure and inflammable air acting on each other through a bladder, is too inaccurate to furnish a decisive inference, as the putrefaction of the bladder might supply some fixed air.

In this introductory part, it will be proper to collect together all the general observations that are to be made on that class of mineral waters, which are commonly esteemed and called sulphureous, before we proceed to the history and analysis of the mineral waters of Aix-la-Chapelle and St. Amand.

The unphilosophical and self-inter-

ested contest that was kept up at Bath for so many years, and maintained with more warmth than good manners or science—whether sulphur, properly so called, was soluble in water, without the aid of an intermediate substance, or an alkaline salt being united with it—gave such a general disgust to the subject, that it will be with great caution I shall venture on the discussion of so intricate a problem; which the ingenuity of all the former chemical inquirers were unable to solve, and the penetration of the philosophers of this age can be barely said to have elucidated.

It can hardly be worth while to examine, with any degree of attention, the various and discordant opinions, which the numerous early writers on this subject, have given to the world, as a more improved



improved chemistry has shewn the greater part of them to be altogether inadmissible.

Before the modern discoveries were known, Dr. Lucas had proposed a theory, which he thought adequate to the solution of the difficulties attending a real sulphureous impregnation of mineral waters. He being fully satisfied that no *hepar sulphuris* was present in them, and finding other modes of union between sulphur and water little agreeable to the facts then generally known, concluded that its existence, in a perfect state, was to be rejected from every species of mineral water.—This Hoffman and Lister had fixed before him; but Lucas advanced still further, and endeavoured by plausible arguments to support an hypothesis, that should account for the ap-

pearance of actual sulphur attending certain mineral waters, and from hence called sulphureous. Taking the received ideas of the component parts of sulphur for granted, he conceived that when accompanying mineral waters, it was formed extraneously : the acid contained in the water meeting with phlogistic matters in the earth, which sublime and meet on the surface of the water, and that the sulphur of them was only to be referred to that combination.

A contraversion of this hypothesis appeared from Dr. Rutty, who supported the opposite opinion with ingenuity, and published in the Philosophical Transactions a general review of the facts and evidences which he imagined tended to prove the presence of sulphur, perfectly formed, in the hepatic

patic waters ; and was indeed able to shew, that its appearance in them was not always owing to external combinations, though he was little able to tell in what manner the water was disposed to a union with sulphur. He observed, indeed, the alkaline salts belonging to certain hot mineral springs, and seems inclined to suppose that the menstruum proper for the solution, was to be looked for in them. The immediate opposition of facts, to the existence of any thing like hepars in the sulphureous waters, obliged many inquirers, who were favourable to the supposition of formed sulphur making a component part of these waters, to adopt an idea that sulphur might be suspended, though not dissolved, by means of a subtle diffusion of it.

Of this class is an author, who pub-

lished his arguments not long before the problem in question received further illustration. In these he attempts to account for peculiarities, in the sulphurated waters, inexplicable on the common principles; and observes, that by sublimation from subterraneous fires, sulphur might acquire a sufficient degree of division to be suspended in water. This, like the preceding opinions, it is hardly necessary to controvert, or observe that it is entirely unsupported by fact, and militates against the general principles of chemistry; as the sulphur, if present, is evidently in a state of union.

At a late period, researches in the pneumatic chemistry detected a permanently elastic fluid, which had been passed over by Dr. Priestley: the more obvious properties of which were, a  
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peculiar fœtor, inflammability when mixed with certain other airs, and a power of discolouring silver and other white metals.

It was found that this gas, when united in a certain proportion to pure water, communicated to it the smell, taste, and many other characteristics of the sulphureous waters.

Bergman, who first began to make regular and connected observations on this subject, found that water artificially impregnated with the air disengaged by acid from hepata, &c. though yielding no precipitate to acids in general, threw down, on the addition of dephlogisticated and highly-concentrated nitrous acid, a powder, which, being collected and dried, was actual sulphur. He observed, that from such waters, silver, dissolved in nitrous acid,

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was precipitated black or dark brown, and the precipitate was fulphurated : and that arsenic, in its pure state, was gradually converted into orpiment. He formed a theory of the composition of hepatic air, on the principles of which he accounted for these appearances, as well as for those of actual sulphur in its concrete form attending the sulphureous waters ; supposing, in the latter case, a power in the pure air of the atmosphere to decompose hepatic gas, by seizing on its phlogiston.

Subsequent researches have been made by Sennebier, Kirwan, &c. by which the properties and chemical habits of this air have been much elucidated.—The effects of certain combinations have appeared rather to militate against some of Bergman's opinions. It  
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is found, that with pure and nitrous gas the hepatic air deflagrates, and that sulphur is deposited ; that when nitrous or vitriolic airs are added to the hepatic, a diminution and reciprocal action takes place, and sulphur is found incrusting the vessels ; that the alkaline and hepatic airs act on each other ; but that with common or pure air no decomposition took place, though they remained together eight days. The action of fixed, inflammable, and other elastic fluids seemed to be little or none.

Dr. Watson, bishop of Llandaff, was led, from the consideration of certain hepatic waters, Harrowgate in particular, to propose a question, Whether they were not impregnated with a peculiar air, which he styled Hepatic, and from which they received their  
characteristic

characteristic qualities ? before he was acquainted with what Bergman had done on the subject of the hepatic gas. He asks, whether this air, and the inflammable air separable from some metallic substances, consists of oleaginous particles in an elastic state ? This part of the conjecture may, perhaps, not be admissible ; but the learned bishop's claims to the discovery of this aerial impregnation ought not to be overlooked, though he modestly gives it up, as well as any future merit in its prosecution, to Mr. Bergman ; who, since this time, has, to the great loss of all true philosophical knowledge, at a time when the highest expectations were entertained of his further illuminations of every part of chemistry, sunk under infirmities and disease, in consequence of his unwearied application to

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the improvement of his favourite science.

The application of the facts before-mentioned, to the composition of hepatic waters is obvious. The manner in which the hepatic gas is extricated in the bowels of the earth, is explained by Bergman, by supposing the decomposition of hepatic matters, which is formed there from the union of sulphur with lime, magnesia, or alkali, to take place by various means. This explanation, however, from the rare occurrence of real hepata being found in these waters, and other incidental occurrences, seems to be still involved in some difficulties. Perhaps Mr. Gengembre's experiments, and some more modern observations on the variety of bodies that seem to be concerned in the production of this air, may throw  
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considerable light on other and more probable modes, by which so important an agent is presented to be combined with different waters in the deep recesses of the earth.

For some time very few substances only were known to yield hepatic air, as the hepata, sulphureous ores of lead, zinc, &c.—We now know, that it is commonly found in coal-pits, and Bergman discovered it in native Siberian iron ; many instances are given, in which wood remaining for a long time in common water has been observed to communicate to it some of the properties of hepatic waters ; and sea-wrack, calcined to a certain point, impregnates water with the smell and taste of hepatic air. Some of the effects of hepatic air are manifested in the putrefaction of certain animal substances ; from  
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the discoloration of silver, as well as by the smell and taste, this fact has particularly appeared in blood. It has been supposed by some writers, that common salt, by calcination, or by putrefaction, will impart to water a sulphureous smell and taste. Sulphur, with oils, charcoal, sugar, and plumbago, will yield hepatic air, when properly treated, according to Mr. Kirwan; who did not succeed in repeating some of Mr. Gengembre's experiments, most probably from the want of a due degree of heat being employed.

In general, the livers of sulphur will not yield hepatic air without the addition of an acid, and the marine acid is best adapted for this purpose.—Every species of hepatic air turns the tincture of lacmofs red. Hepatic airs, extracted from different materials, differ very  
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much in their solubility in water; but the most remarkable appearance in the union of hepatic air with water is, that it is not permanent; yet the water in no degree decomposes the hepatic air. The most sensible test of hepatic air is the solution of silver in nitrous acid; inso-much that, in proportion to the degree with which the nitrous acid is saturated with silver, this, even by contact with hepatic air, however mixed with other airs or substances, becomes red, brown, and black; and these precipitates are only sulphurated silver, and when the acid is not largely saturated with the silver, the precipitate will be re-dissolved. As to the properties of water saturated with hepatic air, it turns the tincture of lacmoss red; it does not affect lime-water; the solution of earths in the mineral acids are not altered.

tered by it; with the marine salt of iron it forms a white precipitate, with the nitrous salt of copper a brown precipitate, and the liquid is changed from blue to green; with copper vitriolated a black precipitate; with a variety of other habitudes, with different metallic solutions, not necessary to be repeated here: and for an accurate account of hepatic air, the reader is referred to Mr. Kirwan's experiments in the first part of the Philosophical Transactions for the year 1786.

The difficulty of uniting the sulphur, if there is any, in these waters, with them, (although true hepata, or livers of sulphur, are rarely to be found in them) does not arise from any want of proper substances to form such a union, for many of them contain both mineral alkali and different absorbent

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earths : whether the diffusion of these substances in so great a body of water renders them incapable of acting with a sufficient force to dissolve the sulphur, or that the degree of heat in the water is not sufficient to form the union, I do not pretend to determine ; but I know that the hottest water in the neighbourhood of Aix - la - Chapelle, and the heat of which far exceeds the heat of any of the springs in the city of Aix, discovers no signs of any hepatic air, though the other contents of this water are entirely similar to what is found in most of the waters in that place. Yet nothing is more difficult and rare, than, in treating the generality of what are called sulphureous waters, to be able to detect, by any test whatever, any real sulphur contained in them. There are some sulphureous

ous waters that, with the addition of a very small quantity of liver of sulphur, will form precipitates with metallic solutions; yet, if you add to them only the pure acid, even the dephlogisticated and highly-concentrated nitrous acid, no precipitate of sulphur whatever will appear.

M. Macquer has remarked, that if you put a few drops of a strong metallic solution into these waters, the hepatic air will disappear, because, he says, this vapour will attach itself to the metallic substance, and thereby lose its volatility.

If such conjectures are admissible in chemistry, it has been advanced by some writers of eminence, that hepars have formerly existed in these waters; but they, through the long lapse of time, have been decomposed, and nothing

remains at this time, but the mere smell and other faint vestiges of them.

And some authors have explained themselves in this manner concerning their opinion of sulphureous waters :—Hepars, they say, naturally tend to decomposition ; the sulphureous part of them dissolves through the dissipation of the phlogiston, which, quitting the acid, this combines with the alkaline substances that had held the sulphur in a state of solution : and this decomposition shall take place sooner or later, according to the nature of the hepar ; if composed of calcarious earths, the soonest : the greater the quantity is, and the greater the exposure on large surfaces, assisted by greater degrees of heat, the sooner it will be accomplished.

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They say also, that the property of discolouring silver, mercury, and other white metallic substances, is a most fallacious testimony of the presence of real sulphur; for many substances, very foreign from the principles of sulphur, will have the same effect. And in the formation of sulphur itself, in proportion as it combines with the intermediate substance it never remains pure, but ever retains some portion of a fuliginous or coaly matter, and which adheres closely combined with it; and that it is this substance which produces the effects of the hepars, in precipitating with metallic solutions; and on this account the precipitate will appear black, very different from the appearance of the precipitate formed with the same metallic solutions in the waters of Aix-la-

Chapelle, and other noted sulphureous waters, as will manifestly appear hereafter ; and, moreover, that these waters do not really contain any substance that is combined with the vitriolic acid.

But in order to close what I have further to say on the subject of hepatic air, so frequently deemed the criterion of real sulphureous waters, Mr. Monnet is of opinion, that this vapour is so far from being always the result of the decomposition of sulphur detached from vitriolic acid, that he thinks it to be purely phlogistic, or nearly so ; and that whenever a pure phlogiston is exhaled, it will ever have the same smell : and a vapour, similar in smell, will exhale from putrifying vegetables, and which will also discolour white metallic bodies. The vapour detached from

from sulphur and iron filings, moistened with water, was never deemed to be actual sulphur, however similar it may appear to hepatic air. If you put a piece of heated pyrites into cold pure water, in a vessel that may afterwards be closed up, it will give the water the taste and smell of a sulphureous one, and it blackens silver; and it is the opinion of Mr. Monnet, that the volatile spirit, which is detached from the pyrite, is confined and dispersed in the water by the decomposition of it. This phlogistic vapour, separated from the acid, remains possessed of all the properties of the mass. A similar effect is produced in forming a sulphureous mineral water in the water of a blacksmith's shop, in which he occasionally quenches his heated iron; and this vapour is so extremely

volatile, that it very soon escapes from the water, and is dispersed in the open air; and the water then will in no respect differ from common water, if no other substances shall remain dissolved in it.

Thus it appears then, that the chemists are not at present on any settled plan of the nature and composition of hepatic gas, though most seem to agree, that sulphur enters into it as a component part. The manner in which that substance is dilated into a fluid permanently elastic, is explained with some diversity; Bergman, who has made the greatest advances towards the elucidation of it, has supposed that the presence of phlogiston is necessary to form the bond of union between sulphur and the matter of heat; and supports his opinion on the easy decomposition of  
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this air by nitrous acid, which he attributes to the avidity with which that acid attracts the phlogiston of the compound, and sets the disunited parts at liberty ; to the same purpose he produces the decomposition by vital air. Mr. Gengembrè, from experiments, in which he observed, that the hepars did not yield hepatic gas, except when formed by the humid way, or dissolved in water, conceives the decomposition of water necessary to the formation of this air, the component parts of which he conceives to be aqueous inflammable air and sulphur, of which the sulphur does not all burn, but is in part deposited during the inflammation of the other part. An experiment made by Mr. Gengembrè, on this subject, is worthy of attention : he exposed sulphur to the focus of a burning-

burning-glass, over mercury, in inflammable air, and relates, that a part of the sulphur was dissolved, while the inflammable assumed the nature of hepatic air: he produces many more facts, to which applying Mr. Lavoisier's principles, he endeavours to support his opinion. The decomposition of hepatic by pure air is readily explained on this theory, as water is formed on the addition of the latter, and the sulphur, deprived of its solvent, is precipitated. One of the last authors, an English one, on this subject, who has treated it with the greatest intelligence and accuracy, and on this account it is not necessary to mention his name, considers this gas as simply sulphur, enabled by the matter of heat to assume an aerial or permanently elastic form.

## ALKALINE AIR AND WATER.

As the common marine acid air may be deemed to be the vapour of the spirit of sea salt; under the same method of treatment, by receiving it into a vessel filled with quicksilver, inverted into a basin with quicksilver in it, an alkaline, though not a pure one, may be procured from the volatile spirit of sal ammoniac put into a thin phial, and heated with the flame of a candle, by which means a great quantity of vapour may be collected, passed through the quicksilver, where it will remain in the form of a transparent permanent air, not condensed by cold. By the same means it may be procured from spirit of hartshorn, or sal volatile, either in a fluid or fixed

fixed form, and from any of these volatile alkaline salts, produced by the distillation of sal ammoniac with fixed alkalies. But from this method of preparing these volatile alkalies, it will be found that this air will contain a greater quantity of fixed air, mixed with some alkaline air in the compound. The best method of procuring a pure alkaline air, will be to make use of a volatile spirit of sal ammoniac, prepared by distillation with slaked lime, which contains no fixed air; and the quantity of pure alkaline air, that by these means may be procured, will be nearly equal to the quantity of acid air detached from an equal quantity of the spirit of sea salt. This alkaline air will be readily imbibed by water, and by its union with it will form a very strong spirit  
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of fal ammoniac, perhaps a stronger one than can be made by any other means. And by uniting this alkaline air with acid air prepared from sea salt, a white salt may be procured in a solid form, which will prove to be common fal ammoniac, or the marine acid united to the volatile alkali.—Fixed air, admitted to this alkaline air, formed oblong slender chrystals, that covered the sides of the vessel with network, and which were the volatile alkaline salts which the chemists get in a solid form by the distillation of fal ammoniac with fixed alkaline salts. The property of alkaline as well as acid airs hastily to dissolve ice, when that substance is exposed to the action of them, has been often observed; the heat, which necessarily passes in such cases from an absolute to a sensible state,

state, during the time that the elastic fluids are attracted and absorbed by the ice, will sufficiently account for the speedy effects of this operation.—The further prosecution of experiments with alkaline air has been anticipated by a previous account, to shew that volatile alkalies may be introduced into mineral waters by other means than what they have been confined to by the generality of writers upon them; namely, the decomposition of animal or vegetable matters by putrefaction.

#### ALKALINE WATERS.

Alkaline waters are distinguishable, besides the piquant flavour and effervescence with acids, by a peculiar lixivious taste, by decomposing many earthy salts in solution, and turning

green the blue vegetable juices: they are all more or less impregnated with fixed air, in consequence of which they exhibit many appearances in common with gaseous waters, though they are in fact of a contrary nature. In the waters in question, the very great quantity of fixed air, which is found uncombined, must almost render it impossible that the alkaline part of their composition should exist in a pure state, or even in one approaching to it; yet the properties which a complete neutralization from so weak an acid would present, can hardly be looked for, as is evident from the effects of combination with other substances.

Several parts of Germany, and Auvergne in France, furnish waters of this kind, taking their principal characters from

from a mineral alkali contained in them. Mr. Monnet has observed, that the mineral alkali is presented in these waters in two different states ; one, in which it is yielded well chryftallized, and fuch as is procurable from the lixivium of foda and marine falt ; but that it is more commonly in a lixivial ftate, as in the waters of Mont d'Or and Bourbon ; and that in fome waters it is fo masked and difguifed, that a great number of the examiners of mineral waters have been baffled in their attempts to investigate the nature of this falt.

The manner in which he conceives the decomposition of the felenite may be avoided, he explains in the following manner : When a loofe mineral alkali is prefent, he fupposes, that in the ftate, which he calls lixivial,

vial, the alkali does not manifest all its saline properties; and relates, that he has made experiments on this alkali with a solution of selenite, which it did not alter.

Till the nature of the waters examined by Mr. Monnet are more exactly known, some ambiguity evidently appears in his account of the state of the alkali in them, which he calls lixivial, and to which he attributes such peculiar properties.

The presence of the mineral alkali uncombined, has often been the cause of great difficulties in the analysis of waters, containing with it other saline bodies, particularly common salt. A mode has been pointed out, by an ingenious physician of Turin, which succeeds very well in separating and ascertaining the quantity of the mineral

H                      alkali ;

alkali; to which Bergman's method was inadequate. Mr. Gioanetti dissolves all the fossil alkali in distilled vinegar, and dissolves the terra foliata, or the natron acetatum, in alcohol, after chrySTALLIZING it. If sea-salt is mixed with the natron acetatum, it is not taken up by the vinegar; from which the mineral alkali is easily recovered, and its proportion to the original mass directly ascertained.

Though the universal dispersion of mineral alkali uncombined with the mineral acids, or as natron under the impregnation of alkaline waters, with this substance, may be easy of explanation; yet the presence of vegetable alkali, which, though rarely, is sometimes found in mineral waters, is not so easily accounted for. It has been in general referred to putrefaction; and  
the

the common methods of producing nitre favour the supposition, as well as Mr. Thouvenel's and Becher's experiments. The large collections or mines of nitre discovered in some parts of the world, as Italy, at some depth in the earth, although their origin is not free from suspicions of mistake, yet this circumstance, confirmed as it is, and some others, might lead us to suppose nature capable of producing it in other manners.

The vegetable alkali has been found in waters within the circuit of large towns, as at Douay. Mr. Monnet relates, that he has procured it in a state of considerable purity, united only to fixed air, from some of the waters of Spa, and which will appear hereafter in the analysis of some of the waters near Spa. And he seems to

think that it is more frequently to be met with in a state of purity than is in general imagined. It is most commonly united, in mineral waters, to the nitrous acid; though instances occur, as will hereafter be proved, of its combination with other substances.

Alkaline waters are most abundant in mountainous countries, and in countries where volcano's exist at present, or have shewn themselves formerly, and they are all charged with mineral alkali; alkaline, as well as sulphureous springs, arise from deep sources; and they are all abundantly stored with aerial acid, which shews itself with quick sparklings as soon as ever they issue into the open air; this ebullition is generally a convincing proof of their alkalinity. Another test of the alkaline waters is the abundance



of absorbent earths they generally contain, which are united to great quantities of gaseous spirit, to distinguish it from common air, which M. Venel supposed only to be contained in such waters, and to which he united some other acid saline body, to account for the brilliancy in their taste.

Nothing more remains to be stated in this general account, than to point out the method that is intended to be pursued in the following analysis. The first and most obvious method of examining any mineral waters, and previous to any investigation of their composition by the rules of art, is by their taste and appearance in the mineral fountain; every person, though little conversant in medical enquiries into their nature and properties, may immediately perceive the difference of

medicinal from common waters, and, at the same time, discern their greater or more remote resemblance to other mineral fountains, with whose qualities he may have been previously acquainted, and thereby be able to arrange them under their proper classes.

If, on tasting any water that is new to him, it shall affect the organ with a lively brisk sensation, and on agitation, or pouring it out of one glass into another, it should sparkle, emit and discharge a number of little bubbles on the surface, and cover the inside of the glass with a great number of small air-bubbles; he may rest assured, that such a water is plentifully stored with aerial acid, which will act as a solvent of its contents. If, on adding to a little of this water in a glass a small quantity of pure vegetable or  
fixed

fixed alkali, no ebullition or effervescence shall ensue, the existence of any mineral acid in it will be rendered doubtful.

The effects of acids and alkalies, in changing the blue juice of vegetables into red or green, are so generally known, that it is unnecessary to mention the distinction of them. The syrup of violets has long held a place amongst the sensible tests of acid or alkali; but Bergman is disposed to reject it altogether, as it is subject to fermentation, and is not sensible of the presence of aerial acid in water; and substitutes in its room the tincture of turnsole, which, from a perfect blue, in a dilute state, will turn red, if fixed air, sufficient to fill only one-fiftieth part of the vessel, has passed through the water; or one part of water saturated with fixed air,

H 4 will

will make fifty parts of the tincture of turnsole distinctly red. The syrup of violets will sometimes turn green, when the substances contained in the water are really not alkaline. Yet the variety of chemical agents that are directed to similar purposes, which exist in nature, has inclined other chemists to keep syrup of violets still on the list of tests, and join its use with the lac-moss, a lake or pigment prepared from the *Lichenes fruticolosi* of Linnæus, or the white mosses that grow on the rocks in the Archipelago, Canary, and other islands, and in commerce it is called Archil or Orseille.

A test which promises, in some cases, to answer our purposes, under this article, better than either of the other, has been pointed out by Mr. Watt, in the juice of the red cabbage.

In

In the application of an agent so important as fixed air, to the doctrine of mineral waters, and of Spa waters in particular, the perfect knowledge of its affinities to bodies in general, and especially those frequently occurring in water, is of the first consequence. The illustrious Bergman, who considered it as a real acid, though perhaps the weakest of all, has determined the relative places of different substances as affected by its attraction—and his exact table of them is therefore here subjoined.—Certain appearances, which might not have been expected, take place in waters abounding with fixed air, and which are worth mentioning here, as capable of leading into mistakes. In those waters in which lime, magnesia, &c. are kept in solution by an excess of acid, the simple addition of

of caustic alkali will throw down a precipitate of earths.

#### AFFINITIES OF THE AERIAL ACID.

Pure terra ponderosa.

Lime.

Pure vegetable alkali.

Pure fossil alkali.

Pure magnesia.

Pure volatile alkali.

Pure clay.

Calx of zinc.

Calx of iron.

Calx of manganese.

Calx of cobalt.

Calx of nickel.

Calx of lead.

Calx of tin.

Calx of copper.

Calx of bismuth.

Calx

Calx of antimony.

Calx of arsenic.

Calx of mercury.

Calx of silver.

Calx of gold.

Calx of platina.

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Water.

Spirit of wine.

The principal precipitants made use of were :

1. Syrup of violets, which in some cases, by coincidence of facts, may give a certainty, from shewing properties different from other analogous tests : and the green it will sometimes shew with iron, is readily distinguishable from that produced by alkalies ; and its fermentation may be readily prevented.

2. The tincture of turnsole obtained from lacmos. — A single grain of concentrated vitriolic acid will give a visible red to 400 cubic inches, or about 170,000 grains of this blue tincture.

And paper saturated with the tincture of turnsole, prepared by boiling with a little starch in distilled water some of the lacmos being enclosed in a linen cloth, is changed with acids to a red ; while alkalies restore the blue colour again, and heighten the original one ; yet this paper is not so sensible of the agents as the tincture.

3. The watery tincture of Brazil wood, which is red, but readily becomes blue with alkalies, and paper prepared with a little starch boiled in the tincture, answers better than the tincture itself. One grain of fresh chrysalized vegetable alkali, dissolved in

4,000



4,000 grains of water, changes the red colour of this paper to a sensible blue : acids change it to a yellow, and restore the red colour destroyed by the alkalis.

4. A saturated tincture extracted by spirit of wine from powdered galls.

This tincture readily discovers iron, and slowly precipitates it out of water. If the metal is in small quantities, the water and precipitate become purple, through different gradations of the shades, in proportion to the quantity ; and when it is large, they both will be black.

A single drop of this tincture will give a distinct purple to a pint of distilled water, in which less than  $\frac{1}{30}$  part of a grain of iron is dissolved.

5. The phlogisticated alkali. This preparation will discover also the smallest

est portion of iron. Distilled water, containing in a pint of it 2 grains of green vitriol, on the addition of a single drop of the lixivium of phlogisticated alkali, instantly shews a Prussian blue; it precipitates copper of a reddish colour, manganese white, and precipitates also other metals.

6. Concentrated vitriolic acid.

7. The acid of sugar is a most delicate test to discover lime, however mixed; a single grain of pure lime in a pint of distilled water, with a small portion of the chrySTALLIZED acid of sugar, shews white and fleecy clouds.

8. Aerated fixed alkali precipitates all the earths and metals from their solutions.

9. Lime-water, dropped into water with an aerial acid in it, renders it turbid; for whatever part of the lime is penetrated

penetrated by this acid, becomes insoluble and fouls the water.

9. Salited terra ponderosa is of the greatest consequence in discovering the smallest traces of a vitriolic acid; as this acid will immediately form a spathum ponderosum with that test, which will not be suspended in the water; and such is the sensibility of this test in discovering vitriolic acid, that it even exceeds the tincture of turnsole in its sensibility of the aerial acid.

10. Nitrated silver, when dissolved in distilled water, will detect the smallest vestiges of a marine acid, which will immediately seize on the silver, and form a salt incapable of being readily dissolved, and therefore is suspended in the water in the form of a white fleecy cloud.

11. Nitrated mercury: there are

two kinds ; one made without heat, which is precipitated by the caustic vegetable alkali in a yellowish white powder, by fal sœdæ, yellow ; by all substances containing marine acid the precipitate will be in large quantities, and of a curdly substance : if made with heat, the marine acid is immediately detected by this solution ; and, should neither the marine or vitriolic acid be present in the water, the mercury is precipitated by lime, magnesia, &c. dissolved by the aerial acid ; but with new chrySTALLIZED vegetable alkali, a single drop of the solution forms thick sensible clouds in the water.

12. Corrosive sublimate may be of use in the discovery of aerated alkali, when in a dissolved state ; but a small piece of the corrosive sublimate will detect the alkali sooner than the solution.

13. White

13. White arsenic can only be useful in waters impregnated with hepatic air, without a genuine hepar in them: wherever the hepar is genuine, the common acids will discover the sulphur; and a small piece of white arsenic is said to have been coloured with a yellow powder resembling sulphur, and formed an orpiment; but I believe this experiment has not often succeeded.

The generality of examiners of mineral waters are abundantly furnished with precipitants; but for real use most of them are unnecessary, as few can discover more of their true contents than the preceding ones, if judiciously managed; and none, I believe, will make their component parts more manifest, and with equal accuracy: superfluous trials tend only to con-

I                      fusion,

fusion, and the heaping experiments upon experiments, without any apparent design, will tend only to perplex, rather than to convince upon any rational grounds.

The fixed acid, when properly understood, constitutes the mineral spirit of all the celebrated mineral waters : for, if this elastic fluid, that possesses all the properties of that subtle acid, be gradually dissipated by exposure to the open air, or suddenly dispersed by heat, the waters will lose all their invigorating powers, as well as their pungent taste and spirit, never to be altogether recovered again, should we be able, by artificial means, to recover it in part, but never, perhaps, in equal quantities, this elastic fluid. Analysis thus, as well as synthesis, perfectly agree on this subject, and suggest very powerful arguments,

guments, why such naturally aerated waters can never be truly imitated by artificial means; for, though art may boast of giving these mineral waters their aerial spirit again in equal quantities, or to plain simple water as much of this mineral spirit as they suppose water is capable of being united with, yet experiments, founded upon true chemical principles, will hereafter prove, that some of the natural mineral waters of Spa do really contain greater quantities of this permanent elastic gas, than any artificial means, hitherto put into practice, are able to communicate to any water whatever.

The investigation of the mineral properties of medicinal springs by analysis, seems to originate from the honourable and illustrious Mr. Boyle.—None of the preceding writers, who

have enumerated great varieties of medical fountains, as well as different common waters, and distinguished them into hard and soft, warm and cold, saline and chalybeate, salubrious and poisonous; yet the waters do not appear to have acquired these arbitrary denominations from the real knowledge of their contents, investigated by analysis, till Mr. Boyle had discovered the use of several precipitants; they knew, indeed, that syrup of violets was changed from purple to red by lemon-juice and vitriolic acid, yet the effect was referred to some particular properties in these bodies, rather than to the acid part of them in particular; and the habitude of alkaline bodies turning the blue juice of vegetables green; and he instances the juice of the blue-bell, was first discovered by Mr. Boyle; he



afterwards gives in his writings a great variety of different appearances, occasioned by acid and alkaline solutions of different metallic bodies, as well as the simple tinctures of vegetable bodies. Du Clos attempted, in a few years after these discoveries, and at the first institution of the royal academy at Paris, the examination of most of the mineral waters of France. Mr. Boyle, twenty years after this period, entered into a more accurate examination of different waters, by the use of a great variety of chemical combinations of different bodies. Hoffman seems to be the first that fully established the fact of what the ancients called nitre, natron, or mineral alkali, existing in various medicated fountains. Vitriolated magnesia, then called the sal catharticus amarus, had been in

great fame at Epfom for many years, and was afterwards difcovered in the waters of Seidlitz, Seidschutz, and various other waters; yet the true compofition of this fubftance remained unknown till the year 1755, when the great Dr. Black, of Scotland, undertook the examination of the nature of magnesia and other calcarious fubftances, and laid the firft foundations of all the great improvements in modern chemiftry. About this time, Mr. Vernel, appointed fuperintendant of the examination of the waters in France, publifhed his commentary on Seltzer water, in which he fhews, that the volatile vitriolic fpirit of Hoffman was not a true mineral fpirit, but, on the contrary, contends that it is no other fpirit than the air itfelf; infomuch that he may be faid to have come nearer to  
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the truth than any other preceding writer; but he never attempted to prove this elastic spirit to be a real acid, but attributes all its effects to the properties of the elastic fluid, common air.

In a minute investigation of the properties of the best mineral waters, it is frequently necessary to collect the elastic vapour, more or less abounding in them; and this process was formerly attended with great difficulty and imperfection; difficult, from the modes in use to collect it, as well as it was imperfect in the defect of collecting the whole of these vapours, or by exposing part of them to re-absorption. The best, and only certain method of collecting these elastic fluids is, by an apparatus, at this time generally well known, and to pass them through

I 4      quicksilver

quicksilver into an inverted vessel of a suitable size, exactly measured as to its capacity, and graduated; by which means the space apparently empty, but which is really occupied by these elastic vapours, may be exactly ascertained; and, by agitating the vaporous fluid with lime-water, introduced into the vessel, the aerial acid will be all absorbed by the lime-water, and the common atmospherical air, should there be any in it, remain in a separate detached state; and then, by deducting the quantity of the latter from the whole bulk of the elastic vapour collected in the vessel, the true quantity of aerial acid evaporated from the water may be exactly known.

It may happen, that in some mineral waters, the phlogisticated vitriolic acid, generally

generally called the volatile acid of vitriol or of sulphur, may be mixed in some small quantity with the aerial acid, but this rarely happens to be the case; and I will take upon me to say, in the celebrated waters of Spa, whose penetrating and active qualities have been ascribed to a volatile vitriolic spirit, that the smallest portion of such an acid does not exist in them; and moreover, the presence of a volatile vitriolic acid is incompatible with the real existence of the aerated alkaline substances, which by analysis are actually found in these waters: not to insist on various other chemical reasons of their incompatibility, had there been any real vitriolic acid in these waters, on the addition of spirit of wine, they would separate their magnesia and lime completely vitriolated. — Vide Bergman's

man's table, in this book, of the affinities of aerial acid.

To complete the analysis of mineral waters, and collect the different substances held in solution in them, the evaporation of the water, most generally by slow degrees, becomes necessary; and the conduct of this process in a proper manner, is of great importance in the discovery of their real contents. The vessels employed in the evaporation should be broad and shallow, as fluids evaporate more or less hastily in proportion to the surface exposed to the action of the open air. The size of the vessels must be determined by the quantity of the fluid necessary to be evaporated, and this quantity will be regulated by the heterogeneous contents supposed to be in the mineral water; if they are abundant,  
less

less water will be required to form an experiment on them ; when the quantity is small, more water and larger vessels will be wanted. Should the vessels not be sufficient to evaporate the quantity required at once, you may add more water, with caution, from time to time. —Glass vessels would be best at all times, but are exposed to great danger of breaking by sudden changes of heat and cold. All the metalline ones are improper, and exposed to corrosion. Stone ware, if smooth and glazed, is freest from any hazard of desquamation in scraping off the substances that are deposited on them, and their smoothness on the inside suffers nothing to lie concealed, as in the irregularities of rougher vessels.

Gentle methods of evaporation are best, to prevent decomposition, or even  
dissipation.

dissipation of the ingredients, occasioned by violent ebullition; and a loose cover should be laid over the evaporating fluids.

Different appearances in the waters will come on in the different stages of the evaporation.

If lime and iron are present in it, when the quantity of aerial acid diminishes, as it will do in low degrees of heat, they will become no longer soluble, and collect together on the surface of the water, and form a pellicle, which, when broke by the agitation of the water in the process, separates into pieces, and falls to the bottom. When the pellicle is formed only of iron, it remains whole a longer time, and appears variegated with different colours, and continues so till all the phlogiston of the metal

is



is dissipated, and the iron becomes in a calceform state, and then it subsides; and both lime and iron will subside before a boiling heat comes on. After the aerated lime and iron have subsided, the salts begin to fall, gypsum first, if there is any in the water. All the saturated solutions with saline bodies will appear in the evaporation, in the due order of their solubility, or such as are the least soluble in water will appear first, and the others in succession, but which is frequently interrupted by the inequality of the quantities of the different saline solutions; generally the martial vitriol is next in order, and the magnesia last of all, or rather it will gradually fall during the whole process, even to the end of the evaporation.

These

These different heterogeneous matters may either be collected as they shall appear, which is preferred by some good chemists; but should magnesia appear in the water, that would interfere with the propriety of this mode, which seems of less importance in general than Mr. Monnet apprehends, and on which he lays so much stress. The salts, when collected as Mr. Monnet directs, will be more or less united with one another, and perhaps had better be separated from one another when all are united in one mass, and the evaporation continued without any troublesome or unnecessary interruptions, till the whole is evaporated, by slow degrees, to dryness.

The most important part, in a just analysis of mineral waters, is the examination of this residuum, and an ex-

act estimation of the different substances it contains, and the quantities of each of them; being first duly separated, to be exactly ascertained.

The generality of modern chemists have sought for certainty in the investigation of the contents of mineral waters by evaporation, and a subsequent examination of the residuum. Tests, as they are called, have been commonly considered as simply indicating the quality of the component parts, and used as serviceable auxiliaries to facilitate the examinations of them, when time and convenience for more extensive researches were wanting, though, for determining proportional quantities, little advantage can be expected from them.

A more extended application of their effects, to the analysis of mineral waters,

waters, as Bergman and Beaumé had before hinted, has however been made; M. Gioanetti applied, some time ago, lime-water, in a very ingenious mode, to determine, not simply the presence, but the quantity of aerial acid in the waters of St. Vincent.

This physician, having mixed nine parts of lime-water with two parts of the waters of St. Vincent, ascertained the exact weight of the aerated lime, formed by the saturation of the calcareous earth of the lime-water with the aerial acid in the mineral waters; and then calculating, after Mr. Jacquin, that 31 ounces of chalk contained 13 ounces of the acid, he determined the quantity of fixed air in a given proportion of St. Vincent's water.

Mr. Fourcroy has proposed several objections to the accuracy of analysis  
by

by evaporation ; for he observes, that the heat used in that operation may alter the principles of the mineral waters in a sensible manner ; and that compounds, dissimilar to those originally residing in them, are presented by the residuum, when submitted to examination. He observes the changes that the loss of the elastic fluids, expelled by fire, must occasion, and the precipitations subsequent to their escape ; and, in a memoir read to the Society of Medicine, endeavours to establish the use of tests, in a pure state, in the analysis of mineral waters, in a manner more extensive and different to what has been generally done.

He advises, that instead of the small quantities of the mineral water to be tried, which are generally made

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use

use of, several pounds weight should be taken of them, and each test added; till nothing further is precipitated: the precipitate being allowed several hours to collect in a close vessel, the mixture is to be filtrated, and that part of it which does not pass the filtre, after drying and weighing, to be examined; and thus the nature of the substance, on which the test has acted, is to be accurately ascertained, and the cause of the decomposition determined.

Mr. Fourcroy gives the application of his principles to the analysis of mineral waters, and describes the order in which the several tests should be applied, according to their power of altering a greater or less number of substances, which it is not necessary to delineate here; but the general idea seems

seems capable, in a variety of instances, of being applicable with great advantage.

A method of procuring the salts of mineral waters, without evaporation, was many years ago pointed out by Mr. Boulduc, and which, however imperfect it may be, will admit of a useful application.

This chemist relates, in the analysis of the waters of Passy, near Paris, that on the affusion of an equal weight of alcohol, the selenite in the water was thrown down in a chryselline form; that, on the addition of more alcohol, the Glauber's salt shot into chrystals; and that, with still more of this vinous spirit, sea salt was discovered, and began to chrystallize.

These experiments have been applied, by subsequent writers, with great

K 2                      success,

success, to a still greater variety of salts, insoluble in spirit of wine, or requiring a very large quantity of that menstruum, as the vitriolic salts will do ; while the alcohol is also employed to take up from the residuum, after evaporation, certain muriatic and nitrous salts, with which it combines very readily, though in unequal quantities.

It may be necessary, before we close this introductory part, with the account of the methods that were actually taken in forming the following analysis of the mineral waters which were selected for that purpose ; and which method was instituted on the comparison of the different modes of analysis that were undertaken, and recommended to others, by the best chemists of the age, for this purpose ; and, by the reconciliation of their various and different directions



rections to the true principles of chemistry, the best supposed possible mode was formed of treating the different substances that were found in the different *residua* of the waters, in order to ascertain the exact quantities of each, and of what combined substances the component parts of the *residua* were severally formed;—it may be necessary, I say, to attend to the great variety of the different substances that are actually and generally found in water.

Very minute particles of flint, lime, magnesia, and clay, are said, by Mr. Bergman, to be found mechanically suspended in water. A curious question might here arise, How far the action of fixed air in water may be extended, in regard to different earths?—and, Whether the common idea,

here expressed by this great chemist, of the suspension of many different bodies in water, by mere mechanical action, was altogether just and true?

The union of fixed air with clay has been demonstrated by Mr. Schreiber, and since by another good chemist and ingenious physician, the account of which is not given to the public; perhaps the excess of aerial acid in water may, in certain circumstances, act on argillaceous earths in the same manner as on other earths. A variety of arguments have been made use of to shew that siliceous earths are insoluble in water, either pure or saturated with fixed air. The appearances of water, &c. in the internal parts of quartz chrystals, would seem to point out an aqueous origin to those bodies; and some observations of Saussure and

Bartolozzi.

Bartolozzi seem to confirm the supposition.

Though water, saturated with fixed air, was unable, in Bergman's experiments, to take up quartz; and though we should not be disposed to allow those of Mr. Achard to be decisive; yet some later researches of Mr. Morveau seem to point out inferences in favour of the action of fixed air. In the experiments of this most excellent chemist, water, loaded with fixed air, had, after a very considerable time, a perceptible operation on the quartz; and from that water a chrystal of the form and nature of real quartz was produced.

Aerial acid is absorbed by all water, but in such unequal quantities, that the proportion of it in different waters will be from  $\frac{1}{100}$  part of their

K 4                      bulk,

bulk, to a bulk, when set at liberty, exceeding that of the water itself. This, as well as pure air, contained also in many waters, occasions the bubbles that appear on the first impression of the heat; and, in proportion as the aerial acid is disengaged, the pellicle and the deposition is formed, which arises from calcarious earth and aerated iron. Inflammable air is found to pass through some waters, and expand on the surface; vegetable alkali is oftener found in waters than has been apprehended by the first chemists; mineral alkali, however, often occurs, aerated, vitriolated, or salited.

It has been before said how volatile alkalies are combined with water, and in a mode different from the decomposition of animal and vegetable substances.

Terra

Terra ponderosa may accidentally appear in it, united with the marine acid.

Lime very frequently, and oftener than magnesia, and both aerated, vitriolated, nitrated, or salited.

Though vitriolated clay, or alum, is seldom found, yet it has been discovered, as was mentioned before, by an ingenious physician, muriated or salited, as well as aerated, in Nevil Holt water. Iron, of all the metals, is most frequently found in mineral waters, most commonly aerated, not unfrequently vitriolated, and may perhaps be found salited. Manganese, copper, and arsenic, very rarely occur in it, as the subject is confined to particular objects. Snow, rain, and spring waters, as well as river, well, and marsh waters, together with sea water, are here passed over.

Mr.

Mr. Venel and Bergman, apprehensive that great degrees of heat might alter the nature of the fixed principles in waters, direct the heat to be employed in evaporation to be continued below the boiling point. Mr. Monnet, to prevent by its motion the admission of any foreign substances, chooses to boil the water. Mr. Bergman's method of evaporation was preferred, except in making a hole in the lid of the covering to give passage to the vapours as they arise, which retarded the operation, and a loose cover applied in the beginning became unnecessary, when the increase of the heat towards boiling dispersed the vapours sufficiently to prevent the admission of foreign substances: and Mr. Bergman's method of gentle evaporation to dryness was pursued: but the  
confirmation

confirmation of the analytic part by synthesis was not minutely attended to in the whole of the processes.

The use of hepar sulphuris, as a precipitate, recommended by many writers, will be more particularly attended to when the sulphureous waters of Aix become the subject of enquiry. —Alcohol, added in sufficient quantity, precipitates all the salts found in waters which are insoluble in spirit of wine; and on experiment it will be found to take up from  $\frac{1}{7}$  to  $\frac{1}{10}$  of its own weight of different nitrated and salited bodies.

The evaporation being continued to dryness; and in every evaporation which I made for experiments on the residua, upon which I could depend, I generally employed a considerable quantity of the mineral water, seldom less

less than two gallons ; the whole residuum was then carefully collected and weighed. In the conduct of the evaporation, the chrySTALLIZATION of the felinite, if there is any in the water, will succeed the first pellicles, and lastly the marine salt, if any in the water, and mineral alkali, and form cubic chrySTALS ; the deliquescent salts can only be found by conducting the evaporation to dryness.

1. The whole residuum was then well dried, and put into a bottle, and alkohol poured over it to the height of an inch : the vessel was well shaken, and shut close up ; and after standing some hours the liquor was filtered.

2. To the residuum, eight times as much cold distilled water was added : it was again shaken, and after some time filtered also.

3. The



3. The residuum was then boiled a short time in a large quantity of distilled water, and filtered again.

4. And lastly, the residuum that now remained was not soluble in either water or spirit of wine.

The presence of iron in the residuum will give a manifest brownish ochrous colour to it : by exposing it in the rays of the sun for some time, the metal will become so far dephlogisticated as not to be dissolved in vinegar ; and then, by pouring distilled vinegar upon it, the aerated lime and magnesia, which remain in it, will be dissolved ; what little of it may then remain, when washed and dried, will shew by the loss of its weight how much has been dissolved by the vinegar.

The acetous solution is to be evaporated to dryness : if it yields a filamentous

mentous substance, which remains unaffected in a moist atmosphere, it is lime ; but becomes deliquescent if it contains magnesia. A diluted weak vitriolic acid will form out of this mass a vitriolated magnesia, like Epsom salt, that will chrySTALLIZE ; and if the base is composed of both lime and magnesia, it will form both gypsum and vitriolated magnesia.

If we refer to the chemical composition of gypsum and vitriolated magnesia, as established by numerous experiments, the exact quantity of each of these substances will be readily ascertained. The part that remains insoluble in the vinegar must be either argillaceous, martial, or siliceous earths : the presence of the first will be determined by the turbid colour it gives to water ; and the two first are both soluble

in marine acid, and both to be precipitated by phlogisticated or plain alkali. The siliceous earth will remain insoluble in the marine acid, and may be ascertained by the blow-pipe.

Nothing now remains for further examination but the four substances, in the order of them reversed.

1st. The residuum insoluble in the spirit of wine, and water of different temperatures; 2d. The residuum taken by the boiling water, and 3dly, by the cold distilled water; and 4thly, The salts dissolved in the spirit of wine.

The residuum insoluble in the spirit of wine, or in water of different temperatures, has been already treated with vinegar, and the results of the solution explained.

The examination of the contents resulting from cold distilled water, in the

the proportion of eight parts of the water to one of its contents, requires the greatest attention. The water holds the neutral salts in solution; marine salt, Epsom salts, and aerated fossil alkali, are common in waters; Glauber's salt, the febrifugal salt, or sal sylvii, and vitriolated tartar, are more rare. Alum was long suspected by the earlier chemists to be one of the most general agents in the formation of mineral waters; this opinion, which was only conjectural, experiment has exploded, and it has been found that alum is a rare ingredient in their composition. The analysis of the waters of Dominique de Vals, yielded alum to Mr. Mitouart: and the same substance was detected by Mr. Opoix in those of Provins. Marine alum enters into the composition of some waters, as

those of Nevil Holt, which baffled the penetration of former chemists; but it is to be hoped, that a matter so long deemed problematical will soon, by the discovery that the ingenious author has made of a salited clay in their composition, when his analysis is given to the public, throw much light on the nature of those truly useful waters.

The nature of the salts contained in solution is best discovered by a slow evaporation. When only one kind of salt is contained in the water of it, after its action on the residuum, the obtaining it by chrySTALLIZATION is sufficiently easy, as well as thereby to ascertain its nature. But it happens most commonly that several kinds of salts are present together in the solution: excepting common salt, all the different salts may be made to assume their re-

L      &      gular

gular chryftals, when the evaporation is carried on in a heat, by Fahrenheit's thermometer, from 176 to 196, till a drop of the folution, let fall on a cold glafs, fhews the appearance of fpiculæ.

When the figure of the falts is not the object of examination, but the fpecies of them, other methods will be pointed out.

The chryftals which fucceffively appear, being collected together, and dried on blotting paper, in fuch a manner as not to expel the water of chryftallization, the proper nature of each falt may be examined according to their habits, form, tafte, &c.

The alkaline falts are to be afcertained by the various precipitants, tafte, habits with acids, &c. ; and diftilled vinegar will readily discover

whether the alkali is fossil or vegetable, forming with the first a foliated chrystallizable salt, and with the other a deliquescent one.

The salts composed of an acid, united to an alkaline, earthy, or metallic base, are to be investigated with a separate attention to,

1st. Their acid.

2dly. Its base.

The combination formed by the union of vitriolic acid with the mineral alkali, agrees in some particulars with the salt resulting from the union of magnesia with this acid; their general properties are however widely different, and an easy method of distinction, is afforded by lime-water. A chrystal of each salt being added to lime-water, the fluid is not rendered turbid by the Glauber salt, but the vitriolated mag-

nesia is decomposed, and the acid uniting with the lime falls to the bottom in the form of gypsum, together with the deserted magnesia.

The marine acid, when combining with fossil or vegetable alkali, yields salts agreeing in many properties, as being cubic, decrepitating in the fire, and in having a taste something similar. A mode of distinguishing the base in these two combinations has been found in the acid of tartar, which, dropped into a solution of the salt of Sylvius, or vegetable alkali united with marine acid, called also digestive salt, precipitates a true tartar; while a solution of common salt is not acted upon in the same manner.

The nitrous and marine acid will also be noticed hereafter, in the examination of the solutions in alcohol.

The



The more obvious methods of distinguishing those various salts that may be mixed in the solution of the residuum by cold distilled water, are too generally understood to require a particular discrimination in this place. Perfect neutral salts are composed of acid and alkali, the middle neutral ones have not a saline but an earthy or metallic base. The substances taken up by spirit of wine will not present any great variety; muriated terra ponderosa, muriated lime and magnesia, and nitrated lime and magnesia, are those which when present in the residuum are commonly held in solution in the alcohol. The process directed by Bergman, of evaporating to dryness, and afterwards treating the residuum with diluted vitriolic acid, though well adapted to the discovery of the bases,

is hardly adequate to the determination of the composition of the acids.

The acids united to the earths are found by the application of a strong concentrated vitriolic acid, a few drops of which disengage marine gas, if present, known by its smell and white vapour; the peculiar odour and red smoke of the nitrous are sufficient to mark its escape: when very small quantities are present, or greater accuracy is required, a paper, moistened with volatile alkali, exposed to the fume, will render manifest the smallest trace of nitrous acid; and a wetted paper any vestige of the marine acid. Farther modes of detecting these acids are abundantly furnished by modern chemistry.

The absolute WEIGHT of 100 Cubic Inches of the different AIRS, as well as their Proportion to Common Air, are thus stated by Mr. KIRWAN.

		Absolute Weight.	Proportion to Common Air.
Common air	—	31. Gr.	1000
Pure air	—	34. —	1100
Phlogisticated air	—	30.535	985
Nitrous	—	37. —	1194
Vitriolic	—	70.215	2265
Fixed air	—	46.500	1500
Hepatic	—	34.286	1106
Alkaline	—	18.160	600
Inflammable	—	2.130	84.3

A TABLE of the comparative HEATS of  
 some different Bodies belonging to the Sub-  
 jects herein discussed; extracted from the  
 general Table constructed by Dr. CRAW-  
 FORD.

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1. Inflammable Air	—	—	21.4000
2. Pure air	—	—	4.7490
3. Atmospherical Air	—	—	1.7900
4. Aqueous Vapour	—	—	1.5500
5. Fixed Air	—	—	1.0454
6. Water	—	—	1.0000
7. Phlogisticated Air	—	—	0.7938
8. Alcohol	—	—	0.6021
9. Vitriolic Acid	—	—	.4290
10. Charcoal	—	—	.2631
11. Quick Lime	—	—	.2229
12. Pit Coal	—	—	.2777
13. Chalk	—	—	.2564
14. Rust of Iron	—	—	.2500
15. ———— freed from Air	—	—	.1666
16. Iron	—	—	.1269
17. Brass	—	—	.1123
18. Copper	—	—	.1111
19. Tin	—	—	.0704
20. Lead	—	—	.0352

T H E  
M I N E R A L   W A T E R S  
O F  
S A L T P E T R A.

**I**T will be foreign to the design of such an essay as the present one, to enter into a discussion of the chemical difference between mixture, diffusion, and solution ; yet it may be necessary to ascertain our terms so far, as to limit the impregnation of any mineral water with a fossil body, of whatever kind it may be, to a perfect solution of it in the aqueous fluid, and that the latter shall remain clear, pellucid, and transparent.

The

The general solvents of all the fossil bodies, with which the various mineral waters have been supposed to have been impregnated, have, by the different writers upon them, been derived from the various acids and acid salts hitherto clearly ascertained, and other acid saline bodies perhaps not so fully understood; from the alkalies and the various alkaline saline bodies and earths properly combined; and the neutral salts, composed of both acids and alkalies, under different combinations.—Now, as all saline bodies admit of a ready solubility in water, these different acids and alkalies, with the various saline bodies, were supposed to be in a proper state to act on the different fossil bodies, metals, as well as every other kind of fossils, by reducing them into a saline state, and render them also

dissoluble

diffoluble in the aqueous fluid ; but the most important impregnation of mineral waters, and which gives to all mineral waters, into whose composition it enters, the most useful part of them for medicinal purposes, is derived from the aerial acid, that forms both fixible and mephitic airs, and which, being intimately diffused through the aqueous fluid, renders it capable of diffolving any other foreign substances that may, by the means of this acid, be combined with water ; for, from its fugitive nature, it has been said to be rather intimately diffused through, than chemically diffolved in the water.

So much has been already said, in the Introduction, on this aerial acid, that it will be unnecessary to enter into any farther account of it, than barely to advert to some particulars that have  
been

been advanced in medical histories relating to Spa waters, and many other mineral waters that may be arranged under the same class.

The existence of this aerial acid in a great variety of mineral waters, and in great abundance in the waters of Spa and Pyrmont, and many other ferruginous waters in particular, and united with alkaline earths and fossil alkali in many of them, has occasioned great mistakes and perplexity in the generality of writers on these subjects; who, being under the inveterate prejudice of the knowledge then prevailing, could not be induced to suppose, that iron could be dissolved in water, but through the solvent powers of a vitriolic acid, notwithstanding these waters contained, at the same time, either an absorbent earth or a mineral alkali, and  
many



many of them both these or other alkaline bodies ; and this led Hoffman to give a different modification to this supposed vitriolic acid, imagining the acid in them still to be of the mineral class, but of a nature different from what is generally styled vitriolic, and of a nature too so volatile, that it always dispersed itself on any attempts to collect it, as if its volatility disposed it to unite itself and fly off with a metallic substance, rather than with the absorbent earth or the mineral alkali.

This difficulty was supposed by some French writers to be more readily got rid of by advancing, that the vitriolic acid could not be obtained from these waters, through the decomposition of the acid by the absorbent earth or the mineral alkali, at the very time that they were submitted to the experiment,

ment, and notwithstanding the universality of this prejudice in favour of the vitriolic acid existing in all these ferruginous waters, and which were from thence, as well as their taste, called *aquæ acidulæ*.—True vitriolic waters were very rarely to be met with at the same time, whereas such waters, impregnated with the aerial acid, were very common.—The singular instance of the mineral waters of Passy, in the vicinity of Paris, being real vitriolic waters, and their situation subjecting them to frequent examinations by the learned members of the academy, contributed greatly to confirm most of the writers on these subjects of the French nation, till within the last twenty years, in their prejudices, as they made the mineral waters of Passy the subject of their comparing other ferruginous waters

ters with them, in order to judge of their comparative merits with those at their own door.

After the long account given in the Introduction of the principal agents in the formation of mineral waters, and their effects in dissolving and otherways adapting the several component parts for medical purposes, nothing more can appear necessary to be said, preparatory to entering on the analysis of the several mineral waters in and near Spa, in the marquisate of Frunchiment, a territory belonging to the prince bishop of Liege, than barely to vindicate the propriety of the method of proceeding in the future analysis of the different mineral waters herein undertaken, and to give a short descriptive account of the country about Spa, the particular situations of the different  
fountains,

fountains, of the mountains surrounding the place, their perpendicular heights, and of what different substances they are composed, as well as the different elevations of the fountains which issue out of them.—When I assure my readers, that I have attentively considered all the various modes of proceeding, in order to form a just analysis of any mineral water, which have been proposed by the first chemists of the age, and of every different nation in Europe where the science has been most cultivated; compared the accounts that each has given of his own mode, with the accounts of all the others; and endeavoured to reconcile every seeming opposition in their measures to the standard of true chemistry, as far as I was able, and on this basis have raised the superstructure of my own; I may flatter

flatter myself that I have, on these firm grounds, attained to the end proposed, much to my own satisfaction; and if it shall appear equally convincing and definitive to them, I shall hope, that the method of treatment of the waters, with the several tests made use of, and the modes of treating the several component parts of the different residua, will be sufficiently justified in the opinion of the public.

The town of Spa is situated at the extremity of a winding valley, on the banks of a rapid rivulet, and is well sheltered by an adjoining hill to the north, and a high ridge of mountains encircling it, at the distance of a mile to two miles and a half, from the south-east quite round to the north-west.

The author of this essay, when he was at Spa last summer, employed some

M of

of the best *geometres* and *arpenteurs*, as they style themselves, of the place, and the adjoining villages, he could find, to take an actual survey of the town and neighbourhood, in hopes, that such a distinct plan of the country would give more precise and distinct knowledge of the relative natures of the different fountains situated in such various aspects, and issuing out of such different strata of fossil bodies, than could be learned by bare verbal description only; and he obtained from these skilful hands, a correct and finished drawing, or *carte topographique de Spa, & les environs*; they took exact mensurations of the perpendicular heights of the mountains, and the different elevations of the fountains issuing out of the sides of them, under his own inspection, and which drawing he brought with him to

London,

London, and has had it engraved by the best artists belonging to Mr. Faden, near Charing-Cross, geographer to the King.

From this chart it may be observed, that only one of the Spa fountains, the Pouhon spring, situated nearly in the center of the town of Spa, rises from the hill to the north of the town, and close adjoining to it; a hill that consists of argillaceous schists, loose argillaceous substances, and earths mixed with ferruginous slate, in large masses; whereas all the other seven fountains have a northern aspect, rise on that side of the encircling ridge of mountains to the south-east, south, west, and north-west, from the town; and this ridge of mountains is formed, in large masses, of calcarious stones, and marbles, and other mineral bodies,

mixed with loose siliceous earths and stones, and whose tops are covered with woods, interspersed with large boggy swamps, filled with water and mud, which are called in the country *Les Fanges*.

Medicinal springs are found not only in the neighbourhood of Spa, but also in the adjoining districts of Malmendy and Stavelot, of which notice will occasionally be taken hereafter.

The most distinguished mineral fountains, within the district of Spa, are,

- 1st. The Pouhon, in the center of the town of Spa.
- 2d. Geronstere.
- 3d. Sauviniere, and 4th, Groisbeeck, nearly together : And,
- 5th. The Tonnelet.

To which may be added the less frequented springs of

6th.



6th. Niverfet.

7th. The Watroz : And,

8. The Barifart.

The nearest of the other seven fountains, in the neighbourhood of Spa, is distant from the Pouhon more than an English measured mile.

As the situation of the town of Spa is in the lowest part of the valley, north of the higher ridge of the mountains towards the south, the cellars of the houses near to the Pouhon, and to the north of it, have frequently much water in them, and which, on a slight examination, appeared similar to that in the Pouhon fountain : all this superfluous water, as well as the medicinal water in the well, is derived from the adjoining hill, called Annette and Lubin, from a cottage or cottages on its summit, where, since the publica-

tion of M. Marmontel's tale on the imaginary subject of their loves, they have been whimsically reported to have lived.

When the Grand Hotel in Spa, very near to the bottom of this hill, was built, a few years ago, the architect, to secure the cellars from the influx of the water flowing from under it, attempted to sink a deep drain the whole length, and behind the building, in hopes of carrying it off by those means; but, before the completion of the drain, and when only part of it was carried to its intended depth, to the great alarm and confusion of the inhabitants, their favourite and most important source of their wealth and support was found quite empty in the morning: for it is the custom of the place to let all the water out of this fountain.

tain, and clean it, every night: and they ran, in great bodies, to the place where these destructive projects were carrying on, and insisted on having as much of the drain as was already dug out, immediately filled up again. When this was accomplished, to their great joy and comfort, the water happily returned to its accustomed course, and, on the succeeding day, the well was found full again, and the mineral qualities of the water to be not in the least degree impaired. This fact was confirmed to me upon the most creditable information, since several of the gentlemen, who gave me the intelligence, have annually visited these medicinal fountains.

The following are the particular relations of the different elevations, and perpendicular heights of the several

M 4                      fountains,

fountains, in the neighbourhood of Spa, above the level of the water in the Pouhon fountain :

	Perp. Heights.
Geronstere fountain -	580 feet.
Sauviniere and Groif-	
beeck f. - - -	490
Tonnelet, f. - - -	260
Niverfet f. - - -	240
Watroz f. - - -	220
Barisart f. - - -	300
The hill, called An-	
nette and Lubin,	180

Beyond the elevations and heights of the fountains Geronstere and Sauviniere, the mountains rise much higher, even to the perpendicular height of 1200 feet above the level of the Pouhon; these heights are covered with woods and thick covers, interspersed

ſperſed with large ſwamps and moraffy grounds.

The Pouhon fountain is to be regarded as the principal ſpring at Spa, both as it is moſt abundant and powerful in the quantity as well as the quality of its iron, and as it retains, longer than any of the other ſprings, its ſpirituous gas, and of conſequence its iron alſo. The other fountains differ from the Pouhon in their general contents, as they all have leſs ſpirituous gas, except the Tonnelet, which contains it in greater abundance than any, of them, even the Pouhon; and they all contain leſs iron, and in part a different kind of abſorbent earth. The Tonnelet is much purer than the others, and is impregnated with leſs of the other contents, as well as iron, than any of the others; and its elaftic  
gas

gas is more volatile and fugacious than that of all the others.

The Geronstere fountain is still more singular, as it is the only one of them that sensibly discovers any hepatic air to be contained in it. The Groisbeeck fountain has been celebrated, through a long succession of years, for its good effects in the relief of disorders arising from calculous concretions in the kidneys or bladder of urine: and a singular inscription upon it records the cure of a German baron, in the middle of the last century, in a similar case as is supposed; in remembrance of which, the fountain is called by his title of Groisbeeck; and that his descendants erected the structure that encloses the spring, in gratitude for the extraordinary cure their ancestor had received through the use of this water.

The

The Pouhon water, as was before said, preserves its spirituous gas much longer than any of the other waters here, and much longer than the generality of gaseous ferruginous waters in common do. And, as the aerial acid remains so long tenaciously united to the iron, after exposing them for a considerable time in a shallow vessel to the open air, although the gas appears, by the loss of the quick lively taste in the water, by degrees to escape, it will be some time longer before the iron will begin to precipitate, and that very slowly, so perfect is the union of the iron with the aerial acid in this water.

And both these circumstances contribute to render this chalybeate water so capable of being sent to great distances from the fountain, and by proper management to be kept in high preservation

preservation for many years. The reverse of all this will be found to be the case with most of the other waters near Spa, but particularly so with the water of the Tonnelet, which may almost be deemed a simple gaseous water; so small is the quantity of any fossil body held in suspension by the aerial acid in it, and so fugitive is the aerial gas, that it begins to pass off, and very rapidly, the moment it is taken out of the well, and will all escape in a very short time.

A few grains of a pure fixed alkali, dissolved in any of these waters of Spa, either absorbs it, or quickens the rapidity with which the aerial acid escapes from them, and so far destroys their quick lively taste, that they soon become as insipid as common water, with the additional



ditional nauseous taste of the alkali; and on adding to them afterwards some drops of vitriolic acid, more than will serve to neutralize the alkali put into them, they again seem, in some degree, to acquire a spirituous taste: and it was this renovation of their spirit, in some measure, that might perhaps contribute to minds prejudiced in favour of this acid originally existing in these waters, in confirming them more strongly in this their error; for, when it was found by real experiment, that a few drops of vitriolic acid would restore the spirituous taste, when it was once lost, to these waters, it was natural to suppose that they were originally endowed with the same spirit, by the same combination of absorbent earth or alkali with the mineral acid, in the bowels of the earth: without considering that this  
renewal

renewal of their spirit was owing to a new combination of this acid with the alkaline bodies, deserted through the volatility of their own, the aerial one.

Every chemist knows, that the union of mineral acid with alkaline earths, produces great quantity of aerial acid; which, possessing a pungent but agreeable acedcent flavour, gave to the Spa waters the name of acidulous, as well as to many others, from very early times: the propriety of which name, in the sense as containing a mineral acid, may with justice be called in question; for all the waters of Spa effervesce with acids; and all the waters of Spa change the syrup of violets green when they are in perfection: both these circumstances are certain proofs of an uncombined alkali being originally in them. Alkaline substances,

whether saline or earthy, tho' saturated with aerial acid, still act as precipitants in consequence of their alkaline nature; and the force which they exert is not changed by the aerial acid, on account of its extreme weakness; for aerial acid cannot effervesce with alkalies, for whenever any effervescence shall appear, it is occasioned by the expulsion of the aerial acid itself, by the addition of a stronger acid, and which occasions the spumescence, and cannot arise from the union of an alkali with the aerial acid only.

In such gaseous acidulous waters the alkali is not only saturated with aerial acid, but they contain this acid in so copious a manner, as to render the subtle tincture of turnsole red, though the contrary appearance takes place with the best syrup of violets, yet the  
waters

waters with propriety are not deemed truly alkaline : this acid, though abundant in all these waters of Spa, is not able totally to repress their alkaline properties, but it is also extremely volatile ; but in chemical strictness, neither the weakness nor the volatility of the aerial acid can subvert its essential properties.

Every chemist, well informed of the nature of phlogisticated vitriolic acid, will be able to distinguish it immediately from aerial acid : in smell, the former is pungent, penetrating, the aerial one hardly sensible : in taste, the phlogisticated vitriolic acid is acrid and nauseous ; the latter is mild, pleasant, and refreshing : the first may be reduced to a liquid form, this always remains in the state of vapour. The vitriolic one will ever, through its superior

perior strength, expel the weaker acid from every kind of base with which it may be united ; and the compounds of every species will every way differ from those formed by the union with aerial acid.—Vide the Table of its Affinities.

So much having been already said on the general principles of this important part of the mineral waters of Spa, it may be proper, before we proceed with the precipitants, and enter on the analysis of them by evaporation, to estimate, by a proper train of experiments, the quantity of this subtle fluid which enters into the composition, on the spot, of each of the principal springs at Spa ; and then to point out in what manner, under proper regulations, the quantity of it might either be increased, as well as the efficacy of its powers ; or

at least to shew in what manner so useful a part of them might be detained longer in action upon the other parts of their composition, whereby the several substances held in solution by the means of this acid would be also increased, or by proper constructions of the buildings inclosing the fountains, the degrees of pressure would be advanced, and less of this volatile elastic vapour would escape, and consequently less of the other contents would be precipitated from the body of the water to the bottom of the well, before they are administered to the invalids that resort from all parts of Europe to Spa, for the benefit of these salutary waters.

The methods pursued, in order to collect the different proportions of the aerial acid contained in several of the principal springs in or near Spa, was to  
fill

fill a glass vessel of a proper construction with each of the different waters; (this vessel contained from 32 to 33 ounces of each, for they are not all of an equal weight, but are all of different specific gravities, and those too very variable in different states of the atmosphere;) and then to set this vessel in a *balneum marie*, as it is called: and, by means of a glass tube properly bent, one end of which was ground, and luted also into the top of the first-mentioned glass vessel, the other end of which was passed into another glass of a proper size inverted, and which when full up to the top, in that position of it, contained between 60 and 70 pounds of purified quicksilver; and, when several fine and dry days had preceded, this apparatus was carried to the several fountains, in order to

make the several processes on the side of each spring, at a time when the waters were supposed, with justice, to be in their highest degree of perfection : and every process was repeated three, four, nay, five times, whenever any little interruption happened in any of the preceding processes, at each fountain. The following table of the different results with each, is estimated by taking the medium of each set of experiments at each of the springs.

The water-bath was always quite cold, when the glass vessel that contained the mineral was first immersed into it ; the heat was then given it by slow degrees ; till, towards the end of the process, it was raised to boiling, which was continued as long as there remained any appearance of

the



the gas passing through the mercury, and sinking it lower down in the inverted glass vessel \* ; and, in order to exclude as much as possible the common or atmospherical air, the glass vessel that held the mineral water was filled up to the top, leaving only room for the ground end of the bent glass to be inserted.

The gas that was carefully collected in these several experiments, in the upper part of the inverted glass vessel, was, by the means of another glass tube, passed from thence through a proper quantity, rather more than a quart, nearly three pints, of lime-water, contained in another inverted glass vessel ; the account of this latter part of

\* When these experiments were made at the Tonnelet fountain, Fahrenheit's thermometer, immersed in the fountain, usually stood at 50 degrees ; in the other fountains from 47 to 48.

the process will be minutely given, after the insertion of the table of different portions of this aerial elastic fluid contained in the several mineral waters on which these numerous experiments were made.

A TABLE of the different proportions of Gas, in the several mineral waters here mentioned.

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Mineral Water.	Ounces of Water.	Ounce measures of Gas.
Pouhon water	- 33.	- 35.75
Geronstere	- 32.75	- 24.75
Sauviniere	- 32.50	- 33.50
Groisbeck	- 32.25	- 35.50
Tonnelet	- 32.20	- 40.75

It has already been observed, that the gas began to pass from the Tonnelet water, the moment it was taken from the fountain, and indeed it passed rapidly

rapidly when the vessel was set in the water-bath, before it received any heat ; and if a proportionable allowance should be made for what thus hastily escaped, although the apparatus was placed close to the well, the proportion of permanent elastic gas in this celebrated spring might be supposed to be higher than 41 ounce measures.

In order to ascertain the quality of this elastic fluid, separated, in the several processes, from the different mineral springs, the only tests that were made use of, in these different sets of experiments (and in which the author of this analysis had great assistance from the abilities and industry of his learned and amiable friend, the reverend Mr. Graydon, of Ireland) were *lime-water* and *nitrous air*.

In its first state, as it passed, none of these different gases suffered any  
 N 4 change

change from the *nitrous air*, but all of them changed the lime from a brownish hue to a milky whiteness, and quickly precipitated the lime, and the gases were all absorbed by it to a 70 or 80th part; this residuum was found to effervesce with the nitrous air in the same manner, and suffered an equal diminution, as with atmospheric air; and it was perhaps no other fluid than a small portion of common air, that occupied the vacant space of the tube at the commencement of each several process.

The gas began to pass from the Sauviniere water, when the water-bath was heated to about - 80 degrees.

From the Pouhon and

Groisbeck - - 90

From the Geronstere,

not till - - 110 or 120

The

The rapidity of its passage from the Tonnelet water has been before noticed.

The civil and worthy Mr. Briart, who lives at the Tonnelet fountain, as well as his excellent brother, now an apothecary of character at Spa, relate several particular circumstances of this mineral water, of their personal knowledge. A very singular one, relative to it, I shall beg to relate from their information.

Every attentive observer of this fountain on the spot, must take notice, in what greater abundance the air passes through the fountain than in any of the others at Spa, and in what profusion it bubbles up through the water.

They informed me, that on any sudden or extraordinary changes in the weather,

weather, the quantity of air that bubbles up is remarkably increased; and that at these seasons the cellars of their own house, and of the adjoining houses, that lie in the direction of the source, are filled with gas to such a degree as to become so many *grottos del cani*; so much so, that the domestic animals learn by experience to dread them when they are in that state. From these repeated observations, the peasants in the neighbourhood of the fountain have drawn an uncommon weather prognostic; constantly expecting bad weather in their harvest-times, whenever they find that their cats express reluctance, and even resistance, against being carried into their cellars; which they always will do whenever the fixed air is abundant in them.

Mr. Briart, who has a perfect command

mand of this water, and can have any quantity of it that he choofes (for there are four diftinct fountains on the fpot, very contiguous to each other, and very fimilar in their powers) was induced, fome years ago, on the perfuafions of a medical gentleman, to conftitute a large bath of thefe waters for the purpofes of bathing; but the water is conveyed into it on the top, which occafions fuch agitation in the water, that it almoft infantly parts with its folvent fpirituous gas, and the furface of the water is very foon covered with a pellicle from the iron, that refracts fuch a variety of prismatic colours, as renders it very difguftful to every one who might otherwife wifh to make ufe of it for medicinal purpofes.

By a trifling alteration in the conftitution of this bath, and reducing the  
fize

size of it, (for the present dimensions are so large, as to make a frequent change of the water in it tedious and troublesome) the water from the fountains might be readily conveyed into the bottom of it, and all the agitation of the water thereby prevented, and the rapid loss of the aerial gas in a great measure prevented; and a commodious cold bath might be constructed at the Tonnelet fountains, of a mineral water in its highest state of impregnation with fixed air. But I shall at present leave the proposal to the consideration of the medical world at large, how far such a bath might be useful, and in what diseases.—I know of no such bath at present constructed in Europe, at least of none that with proper attention might be so easily formed, and at the same time so abundantly possessed of such



such powerful agents, and which the great quantities of water that flow from these copious fountains would allow to be so frequently changed, and the active powers of the bath to be restored many times in the twenty-four hours. Should any person be desirous to have so commodious a bath constructed, Mr. Briart is ready to give leave to have it made, and to assist also in the expence of the construction.

Before I quit this part of my subject at present, I shall beg leave to give some general observations on the other singular fountain near Spa, the Geronstere, before I proceed into a more particular enquiry into it, and the future analysis of the water, as they have been sent to me by my good friend Mr. Graydon, whose assistance I have before gratefully acknowledged, and who

who made and repeated many of the preceding experiments after I had left Spa, and in whose sagacity and fidelity I can place the utmost confidence.—He writes to me, from Dijon, in this manner : “ The peculiar quality of the  
 “ Geronstere water still continued to  
 “ give me no small perplexity.—From  
 “ the taste and smell, both which it  
 “ loses on the application of heat, it  
 “ appears clearly, at first view, that it  
 “ contains another gas, and of a dif-  
 “ ferent species from that of the other  
 “ waters ; but, as this water gives out  
 “ a gas that will equally precipi-  
 “ tate lime out of lime-water as those  
 “ of the other fountains do, as far as  
 “ this circumstance is to be deemed  
 “ a certain test of fixed air being dif-  
 “ fused in a mineral water, it appears  
 “ to me also as certain, that the por-  
 “ tion

“ tion of hepatic gas must be in very  
 “ small quantity in this water.”

In the course of some other processes which he made with this water, he met with some circumstances that appeared to him a little extraordinary, and I shall beg leave to communicate to the public his own account of these difficulties, for their consideration, in hopes to obtain some further light on a subject, which may appear, as a physical enquiry, not a little intricate, though the solution of these difficulties may not throw much light upon it in a medical view.

“ The air, for some time after it had  
 “ passed, had the same hepatic smell as  
 “ the water before had; but when it  
 “ had stood some hours in the receiving  
 “ bottles (in which, by neglect of  
 “ the servant, a very small quantity of  
 quicksilver

“ quicksilver had been left in their  
 “ necks, with a little of the water that  
 “ came over) the hepatic smell went  
 “ off, so far as to be no longer sensible,  
 “ and the gas now differed only from  
 “ that of the other waters by a very  
 “ light and barely sensible odour,  
 “ which it is not possible to define or  
 “ even to describe.

“ After this observation was made, I  
 “ was desirous to get a greater quan-  
 “ tity of the gas from this water, to try  
 “ if any further and different processes  
 “ could illustrate the real nature of it ;  
 “ and, for this purpose, wished to pro-  
 “ cure larger vessels filled with Geron-  
 “ stere water ; but nothing of that kind  
 “ could be obtained in Spa, except  
 “ the double bottle that had contained  
 “ the quicksilver that had been made  
 “ use of in the other processes : and  
 my

“ my assistant having cleaned it, as he  
 “ thought, perfectly, filled and adjusted  
 “ it as the other vessels had been; yet,  
 “ in this process, the air, as soon as ever  
 “ it passed, even on its coming through  
 “ the quicksilver, had not in any de-  
 “ gree the same smell as the fountain  
 “ water had.—When the operation  
 “ was over, I had the bottle emptied,  
 “ and examined it particularly, and  
 “ found a considerable crust of a calx  
 “ deposited by the mercury, and ad-  
 “ hering to the inside of the bottle.

Whether this had any or what in-  
 fluence in determining the result, he  
 cannot, he says, take upon himself to  
 determine, or to give any satisfactory  
 opinion about the effect; neither dares  
 he presume to affirm, that it might not  
 have arisen from some defect in the ap-  
 paratus, though it was in every respect

the same as had been used in all the other processes, from the beginning of our enquiries, except in the large size of the bottle ; and he laments, that he had it not in his power to make any further experiments that season, to clear up the difficulty ; for the weather continued all the time so constantly wet, and the rains so violent as to spoil the fountain water entirely ; which deprived him of all hopes of success at that time, to extricate himself out of this peculiar perplexity. Having before thrown out some hints of the improvements that might be made in the quantity, as well as the active powers, of the spirituous gas, in these singular mineral waters, the long continuance of my friend, Mr. Graydon, at Spa, even till the approach of winter, gave him still more convincing proofs of the propri-

ety of them, as well as the impropriety of the present constructions of the basins that enclose all the mineral springs; and the last unfavourable season, towards the conclusion of it, gave him very striking instances of the inconveniences arising from the present situation of the Pouhon fountain in particular, as well as ample experience of all the possible ill effects of bad weather upon the waters, through the present form of its enclosure.

Sunk as it at present is, in a hole three or four feet below the street, nothing can be more obvious, than to suppose, that whenever any heavy rains fall, some of the dirty water will find its way into the basin; and, in a letter which I received from my learned and ingenious friend, after he had left Spa, I am informed, that he had had an op-

portunity of seeing such an event really take place; for one morning, after a very wet night, the fountain was found covered with a layer, some inches deep, of dirty water from the street; and, what appeared most singular, was, that it floated over the mineral water, almost distinct from it, and hardly any part of it was mixed with it, and afforded a striking instance of their different specific gravities.

It was conjectured to have entered the basin by the passage through which the surplus of the mineral water was carried off; for the water flows into the well in great profusion: but the possibility of such an event taking place, is certainly a great defect in an object of such importance to mankind in general; and this defect may be mentioned with the less reluctance, as  
it



it is one that may be very easily rectified, and at a trifling expence, and there is reason to suppose, that this defect might not only be readily prevented, but that the powers of the water might be greatly improved at the same time, as has been before suggested.

Let us suppose, that the funk court, or area, wherein the Pouhon fountain at present stands, was filled up to the level of the street, or a little above it, and at the same time the masonry enclosure of the fountain was raised at least to the same level ; and of course the water in the well raised as high, or as far as it would rise ; and this might be easily tried, though I have not the least doubt of its rising to the same level, when I consider the nature and height of the hill from whence it is derived.

§ 3. *Now to be But,*

But, as this fountain is so precious, in the opinion of the inhabitants of Spa, the smallest insinuations of making any alterations in the structure of its enclosure, would create infinite alarms in the place; and therefore another fountain might be attempted to be made, either above in the street, or lower down, below the present situation of the Pouhon; or perhaps with greater propriety on the other side of the street, or still higher up, and opposite to it, nearer to the hill from whence all its medicinal stores are drawn.

I cannot have the least doubts of plenty of medicinal water, and with equal powers with those of the present spring, being found there, from the frequent instances of finding the same kind of water in the different cellars  
of

of the inhabitants to the north and north-east of the Pouhon. And moreover, by a proper construction of the new fountain, and its enclosure, the medicinal water contained in it might be still rendered capable of receiving superior qualities, by judicious management; for, by increasing the depth and the volume of the water, you will increase its pressure, and thereby compress the aerial acid into closer contact with the substances held in solution, and, by the confinement of its active powers, retain greater abundance of it in the well, as well as of the different substances that may offer themselves to its action; such a compression has manifestly taken place in the original composition of the Tonnelet, in its passage towards its source, however purer it may be from the va-

rious substances contained in some of the other waters in the environs of Spa, that are derived from a different origin than that of the Pouhon.

Such an improvement in the qualities of the mineral waters would render them still more salutary, in the relief of a variety of diseases, and of course increase the number of visitors that come annually to Spa for the benefit of these waters; and silence, at the same time, the fears of the inhabitants from any innovation being made in their highly-valued Pouhon, and exhilarate their spirits in seeing so much additional company.

The good bishop might rest at ease, that the profits of the gaming-tables would suffer no defalcation, as well as the magistrates of the *Communauté de Spa* on the same account; and flatter themselves

themselves also with the pleasing hope of greater accumulations of wealth by the same *pious* means.

*Hoc fonte derivata præda*

*In patriam populumque fluxit.*

IN BLUOW STOTAW ISLONN ON

While we are upon this part of our subject, it may not be improper in a medical view (the chief design and intention of these observations and experiments, rather than any refined chemical analysis of these waters) again to advert to the long-celebrated effects of the Groisbeeck fountain, adjoining to the Sauviniere, in calculous complaints. Whether the noble baron whose title it bears, and whose descendants have erected a monumental record of his perfect cure from the use of these waters, really laboured under such complaints cannot now be certainly

tainly ascertained, as the event took place far more than a century ago.

The traditional history of the baron's complaint assures us, that it was occasioned by stones both in his bladder and kidneys ; to such a relation it may not be improper to add some additional credibility, by giving a short history of a boy, about five years old, that was sent to Spa in the spring 1787, from Paris, and to whose case, for my own information, at the time, I paid particular attention, from the middle of July in that year, to near the middle of September, when I left Spa. This boy, from early infancy, had shewed signs of great pain attending his making water, and after it, and his urine was frequently bloody ; he was sent to Spa for the first time in the summer 1786, and was supposed to have

have received great benefit from these waters, and passed the winter very comfortably after his visit to Spa ; till, in the month of April 1787, he complained of pain in passing his urine, and it was observed to stop very suddenly during its passage, and became again bloody : his nights were constantly restless, attended with frequent startings in his sleep ; he gradually lost flesh, and in a short time became weak and emaciated. This patient was never searched for a stone in the bladder ; and was again sent to the Groisbeeck fountain early in the summer 1787. When I first saw him, in July of that year, he was in a course of taking, young as he was, four glasses, of 12 ounces each, of the water, mixed with a little milk, in the space of two hours, every morning : he appeared at  
that

that time lively and in great spirits; told me, with much seeming joy, that he had no pain when he made water: though afterwards, about once in a fortnight, he had some slight returns of pain in passing his urine, that continued four and twenty hours, without any other attendant symptoms. I left him at Spa, free from those slight returns of pain; he had regained all his flesh, was fresh-coloured, lively, and active, and ran about the walks, near the fountain, with great ease to himself, and appeared free from every inconvenience from his malady.

The Caroline mineral waters at Carlsbad, on the confines of Bohemia, which were discovered towards the close of the fourteenth century, are celebrated for the relief frequently obtained from their use in cases that arise from  
calculous



calculous concretions in the kidneys and bladder of urine, and are described by different writers upon them to be an alkaline water, of a superior degree of heat to those at Bath, in Somersetshire, even to be intolerable to the human body till they are suffered to cool. They are said to turn green with the syrup of violets, and to strike a faintish purple with galls, at the fountain; with a solution of corrosive sublimate, to precipitate an orange-coloured powder; and with all the acids, even the weak one of vinegar, are said to make a great ebullition: and on adding ten drops of vitriolic acid to two ounces of these waters, the acidity of it was totally destroyed; and this mixture, on evaporation, is said to have yielded a tartarum, or kali vitriolatum. They give no sense to the smell of any hepatic

patic air in them. Notwithstanding that some of the writers upon the Carlsbad waters, style the salt precipitated from them, when the vitriolic acid is added, a vitriolated tartar, yet others say, and with more apparent probability, that the alkaline part, the principal impregnation in these waters, is the fossil alkali, and the precipitate a natron vitriolatum; in the composition of them the fossil alkali is largely combined with the aerial acid; and from such a combination the beneficial effects of the Caroline waters are more fully ascertained, in the relief of calculous disorders, than by referring the cure entirely to the aerial impregnation, as several authors have done: on the same principles, the good effects of the Groisbeeck waters, in similar cases, have

have been celebrated for a great length of time.

The sanguine advocates for the success attending the use of the *aqua mephitica alkalina* in calculous cases, will take pleasure in the history of the Parisian boy's relief; as it will hereafter appear, that the mineral waters of Groisbeeck contain a certain portion of vegetable alkali, as well as a small portion of the fossil alkali; and, in the opinion of Mr. Margraaff, the vegetable fixed alkali exists in nature as distinct and completely formed as the fossil alkali. On dropping a few drops of vitriolic acid on the last deposit from the Groisbeeck waters, it formed a vitriolated tartar, which it would not have done had the fossil alkali alone been combined in these waters; and this fact may be deemed a further confirmation

mation that the mineral waters of Spa do not contain any vitriolic acid in their natural state.

I shall now proceed to the habitudes of the different waters of Spa, when mixed with different substances, as well as with the different precipitants ; and, after the further examination of their different contents obtained by evaporation, close the account with a general table of the results of the different experiments made upon the principal waters of the place.

All the acids cause an ebullition with the waters of Spa ; distilled vinegar, as well as vitriolic acid : but the concentrated acids occasioned a very considerable ebullition, and great numbers of bubbles to rise on the surface, and to cover all the sides of the vessel, when the waters were fresh taken from  
the

the different fountains. But a dilute tincture of turnsole, made from a solution of lacmofs in boiled distilled water, shewed evident marks of the aerial acid existing in them all, by changing it from a violet blue to red, with various shades of the colour from ruby red to pink, in proportion to the quantity of water made use of, and the quantity of the impregnation in the different waters.

On putting two or three drams of a solution of lacmofs into a tall glass that might hold about four ounces, and adding some of the Pouhon water taken fresh at the fountain, the colour changed from violet-blue to ruby-red, which increased in the brilliancy of the colour till the whole of the water was added ; the same happened with all the

other

other waters, except in the variations of the shades of the same colour.

When this mixture was exposed in a large broad saucer to the open air, and left there for an hour or more, on the gradual escape of the aerial acid (for no mineral acid would have passed from it in the time, suppose it to have had whatever degree of volatility you could give to it) the colour gradually changed again to the blue colour of the tincture of the lacmofs; and in a longer time, two hours or more, the contents of the water, together with the colouring matter of the pigment, subsided gradually in blue flocculent masses to the bottom of the saucer; and afterwards, on adding to the mixture some drops of vitriolic acid, the blue again disappeared, and the mixture became of a pale pink; and, with  
a few

a few more drops of vitriolic acid, by degrees the whole of the deposit was again dissolved, except a small quantity of a substance that appeared like iron in a calceform state.

Milk boiled with all the Spa waters suffered no coagulation, but became rather more dilute and thin.

Soap, in solution with all these waters, formed an equable uniform mass; but, on dropping a single drop of vitriolic acid in a pint of the solution, it immediately curdled into grumous masses, and in standing a short time a perfect decomposition was formed, till at length all the oily parts were detached, and floated on the surface in a separate body.

MEDICINAL REFLECTIONS ON THE  
 PRECEDING EXPERIMENTS, AND  
 THE ALKALINE NATURE OF THE  
 SPA WATERS STILL FURTHER CON-  
 FIRMED.

The alkaline nature of the waters of Spa manifestly appears from these experiments; yet such has been the ignorance of their real composition, that the generality of authors, under the prejudice of an opinion delivered down from their predecessors, without the least appeal to fact or experience, have absolutely prohibited the use of milk in a course of Spa waters, whereas nothing agrees better with them than milk, during the whole time of their use. Similar too, and on the same ill-founded



founded ground, have been their objections to the medicinal use of soap together with these waters, as suffering decomposition through their imaginary vitriolic acid ; whereas soap, combined with the warm detergent gum-resins, forms a most excellent co-operating medicine with the Spa waters, in all disorders of the stomach and bowels, from either obstruction or debility : but, in order to remove further every alarming idea of the styptic effects of the Spa waters, I shall relate the appearances of them with some other precipitants, as they are called, whereby it will appear that the use of these waters may be extended to various other diseases, in the relief of which the use of them has suffered an equal prohibition, without daring the hazard of an appeal to trial or experience.

Chryſtallized alkali produces no other effect with them, than depriving them of their pleaſant pungent flavour, by the immediate abſorption of the aerial acid.

And the cauſtic fixed alkali, after twenty-four hours ſeparated only, and that too in a very ſmall quantity, and very ſlowly, a whitish calcarious powder.

Salited *terra ponderoſa*, the quickeſt and the moſt certain teſt of vitriolic acid, by eagerly uniting with it wherever it appears, and forming the ſpathum ponderoſum, made no alteration whatever with any of theſe waters, except the very ſingular one at the Geronte fountain; in which it will hereafter appear, in the analyſis of them by evaporation, that a variety of ſelenite

nite \* was only found in this water, to the very small quantity of less than half a grain in a quart.

The blue vegetable juices are in general, though unequally affected, made

\* When you are searching for felenite in mineral waters, the ordinary appearance of it on chrySTALLIZATION, in the form of needles of a larger or of a less size, is not to be expected always; for, on obtaining the calcarious earth in many of the mineral waters which are the subjects of our present inquiry, and on dropping the vitriolic acid on some of them, to form a true felenite, not before existing in them, such a one will be obtained, notwithstanding it will exhibit in chrySTALLIZATION a great variety of changes in the form of the chrySTALS. Every person conversant in such experiments will soon be convinced, that these varieties really take place in nature, which has been by some authors attributed to real varieties existing in the same absorbent earth; and Mr. Monnet has taken notice of these different appearances.

red by acids ; but all the waters at Spa strike green with fresh syrup of violets, notwithstanding the presence of the aerial acid, with which it has no immediate action : all the alkalies in general strike green with the vegetable juices.

The red watery tincture of Brazil-wood becomes blue with the alkalies, and has the same effect with all the waters at Spa.

Alkalies also affect the yellow watery tincture of turmeric, by subfuscating it to the brown colours, in proportion to the quantities of them : the same will be the effect with paper tinged yellow with this tincture ; and all the waters at Spa have the property of communicating to this yellow paper all the shades of brown.

The acid of sugar, and the saccharated

rated vegetable alkali, precipitated a small quantity of lime in the Pouhon water.

Alum, with these waters, deposited its earth.—A solution of mercury, made without heat, yielded a brownish yellow precipitate, as did the corrosive sublimate also; but if the solution was prepared with heat, the precipitate was of a paler yellow colour.—And a solution of silver with these waters by the alkali, saturated with aerial acid, formed a fine white precipitate.

Having thus fully established the alkaline nature of these waters, by such numerous and various tests, many of which may appear tedious and useless; and indeed after what had been advanced, in beginning the trial of them with the precipitants, these additional

tional experiments may be deemed unnecessary testimonies in support of an opinion that was no longer dubious ; yet any attempt to extend the use of these waters to disorders for which they have ever been esteemed improper, if not noxious and destructive, may be exposed to censure, and the presumption be thought highly culpable, if the foundations of the principles, from whence the inferences are deduced, had not previously and amply been secured.

That the gaseous mineral waters of Spa are abundantly impregnated with aerial acid, and many of them contain it in greater quantities than can be communicated by any artificial means to water, as will appear from the table before given of the different quantities

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ties of aerial acid to be collected from these waters, is another fact that has been also fully established.

When I recollect also, that, during my residence at Spa last summer, I found that the laborious peasantry of this country indiscriminately made use of these waters, from the fountain that was nearest to the place of their labour, to support themselves under the fatigues of their work, exposed to the heat of the sun, in the same manner as in other countries they make use of fermented liquors; and regularly brought their bottles to fill them again at the fountain when they wanted a fresh supply; and that they did this constantly, without any inconvenience to themselves, but to their great comfort and satisfaction; and a more healthy

thy and active set of labouring poor I never saw in any country.

Various have been the methods devised by ingenious physicians of administering fixed air, for medicinal purposes, in a number of internal diseases, as well as externally in cancerous, putrid ulcers, and foul eruptions; and these, for very worthy ends, have been communicated to the public, for enlarging the views of other practitioners, and exciting them to make trials of it in similar and other disorders; but their noble designs have not been attended with all the success that was to be hoped and expected from them: and I do not recollect a single instance, from report, of any invalid being sent to Spa last summer, out of the common track of Spa patients, as they were called long before



before the real nature and uses of these most excellent mineral waters were truly and justly appreciated.

It has before been laid down, that milk of all kinds mixes equably and uniformly with all the waters of Spa ; and there is not a single instance that milk ever disagreed with any person, from the bare use of the Spa water at the same time ; and therefore, whenever a milk diet is proper, that will be no objection to the use of Spa water with milk.

Whether it arises from the generality of consumptive patients being sent too late to the hot-wells near Bristol, thro' the fears of alarming the patients themselves with the opinion that it was necessary to send them to those wells ; or from what other cause, not difficult to devise ; the annals of the deaths of such patients will sufficiently prove,  
that

that of all the disorders, for the relief of which these springs are celebrated, fewest of the phthifical cases certainly receive benefit from them ; which by some people has been thought an ample testimony of their inability to remove diseases, which, perhaps, thro' the delay in their trial, were become absolutely incurable. They certainly diminish febrile heat, and, from their calcarious principle, are absorbent, and gently styptic : but how this substance could render them in any degree antiseptic, is not so obvious ; but, when the whole language of medicine was made up of septics and antiseptics, no wonder that Bristol water was arranged under one of those classes ; and antiseptics are certainly most favourable to the cure of consumptions.

Great has been the relief obtained  
in

in the worst consumptive cases from the use of fixed air; and steel administered in small doses, in judicious hands, has frequently been found useful in guarding against the progress of consumptive disorders; and this principle will hereafter be found combined in the mineral waters of Spa in small quantities, and under the best mode of combination, through the solvent powers of the aerial acid. Whether or no a useful medicine may not be here offered under this form, diluted in large quantities with milk, and taken from the purest of these gaseous waters, may be worthy of the attention of the medical world.

Every species of the diseases so strangely styled scorbutic, whether they appear as rheumatisms, or some particular kinds of asthmas (and are ge-

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nerally

nerally supposed to arise from some particular acrimony in the fluids, that cloak to all our ignorance, and deform the skin with various discolorations and filthy eruptions) may possibly receive more relief with the Spa waters judiciously administered, both externally and internally, than with any other kind of mineral water; and Bladud hogs, by a previous use of the sulphureous baths and waters of Aix-la-Chapelle, might have been cured of their scrophula; and by a subsequent use of the waters at Spa, have prevented a return of their disorders, as well as with the waters of Bath.--Every cause of debility arising from the colica pictonum, or the colica Damnoniorum of England, as well as the enervating effects of other metallic poisons, especially the improper

per uses of mercury, may here find a certain method of relief.

That a fever is a real effort\* of all-indulgent nature, to expel some morbid matter received by infection, or from the obstruction of the regular secretions of the habit, or various other concurring causes, from intemperance and irregular modes of living, is a doctrine of such established truth, and so much confirmed by every mode of rational practice, as not to be readily overset by the opinion of some vain speculative theorists; who, being entirely ignorant of the difference of animal heat, as well as other matters of heat, from actual fire, suppose that a fever may be extinguished with the same ease by cold air, as all other inflammable matters in a state of combustion may with a

\* VIS MEDICATRIX NATURÆ.

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bucket

bucket of cold water. And Hoffman, hastily enlisted under the banners of this extinguishing system, is inclined to give it his support ; yet, when he is pressed to explain how the mode of its action can be ascertained, is forced to acknowledge, that cold water is of such powerful efficacy in exciting febrile motions in the nervous system, as may contribute to resolve obstructions in the smaller vessels, and discuss the adhering morbid matter.

Although I profess myself no advocate for the warm regimen in the treatment of either common febrile disorders or eruptive diseases, and have ever treated my patients in a different manner ; yet I am not disposed to believe the use of cold baths are proper in every febrile indisposition, or that they can ever be used with propriety in ob-  
structed

structed habits from diseased viscera; and am well assured, that many incipient diseases of the viscera, as well as chronical disorders of some continuance, such as the jaundice, obstructions of the biliary ducts from calculous concretions, as well as dropical complaints from visceral obstructions, may receive great relief from the powerful agents contained in the waters of Spa, especially when the patients are duly prepared for the corroborant effects of them by a previous use of the warm baths and mineral waters of Aix-la-Chapelle.

And I am clearly of opinion, that these salutary effects are occasioned by the action of the gaseous spirit, united with the detergent stimulant effects of the pure highly-attenuated solution of iron in these waters, immediately af-

fecting the sensorium ; whether it may or may not excite any febrile motions in the system, yet they will be such as may be productive of good events in the end, together with the sedative effects of their alkaline nature in quieting all the tumults and troublesome effects of flatulence in the first passages.

And from these effects on the sensorium, or the origin of the nerves, new vibrations will be excited in every branch of the nervous system, for the accomplishment of so desirable purposes ; and at the same time the waters will tend to restore the tone, and invigorate the animal powers to get rid of such obstructions in the habit, and every other impediment, as far as the progress of the disease will admit, to regain a regular discharge of all the animal functions.



To proceed with the remaining precipitants, whose effects have not yet been related; but previously some further particulars may be noticed, with some of those already subjected to trial for general purposes.—The singular attachment of the salited terra ponderosa to the vitriolic acid was before observed, and wherever that acid exists in any mineral water, it will ever attract terra ponderosa with such eagerness, as to desert every other basis, and combine itself with this earth with such force, that the small united particles remain indissoluble for the future.—The attachment of the marine acid to silver is as singular as that of the vitriolic acid to terra ponderosa; for, with whatever other base it may be united, on adding to the mineral water some drops of nitrated silver, it immediately unites with

the acid, should any exist in the water, and forms a precipitate in small particles.

All the waters of Spa, from the volatile nature of their aerial acid, suffer great changes in the quickness of their taste, brightness of appearance, as well as in the quantities of the substances held in solution in them by means of this acid, through the various changes and states of the atmosphere; and in the various experiments I daily made upon them for two months together, with the precipitants as well as by evaporation, I hardly ever found exactly the same appearances in them, or the same results, as to the quantity of their contents, for two days together; and the patients constantly observe, that the waters are daily changing in what they call the goodness of them, or their degrees

degrees of perfection ; and all of them, when exposed in wide shallow vessels to the open air, suffer different changes in different times, in different states of the atmosphere : as the acid is more or less fugacious in the different waters, even these degrees of volatility will suffer great variations in different temperatures of the air, or as it is more or less moist ; for, in proportion as the aerial acid shall escape sooner or later in different seasons, or in different parts of the same day, they will also sooner or later lose their lively and quick taste, and become in more or less time foul and insipid, and more or less of their contents will begin to subside ; which can never be deemed the effects of elective attractions to form different combinations, but are only different precipitations, by the bare subsidence

of their contents deserted by their solvent acid, and in different proportions, and in different times; hence, unless the same modes of examination are continued for some length of time, and on the spot, no certain determinations can be formed of their general contents; and hence we meet in authors with such different results, collected from a few desultory unconnected experiments.

A solution of mercury made without heat, in the nitrous acid, will throw down a copious yellow precipitate in the Pouhon water, when it is in the highest state of perfection; but in a moist damp state of the atmosphere this appearance will not always, and indeed seldom take place, and in small quantities; for when neither vitriolic nor marine acid is present in the water, the  
mercury

mercury is precipitated by the alkali, and also by lime or magnesia dissolved in aerial acid: when the water is in its best state, a single drop of the solution will in half a pint of it form a visible cloud.—If the solution is prepared with heat, it becomes more dephlogisticated, and the precipitate will be of a yellowish white, and soon becomes white.

When neither a vitriolic or marine acid are present in the water with nitrated silver, fossil alkali, aerated lime, or magnesia will precipitate the silver in the form of a white powder; but the quantity is not ascertained, as this also is greatly dependant on the state of the atmosphere: and the same happens with acetated lead.

And salited lime will be precipitated by fixed alkali in the waters,

ters, after they have stood for some time.

Though the chemists have observed that precipitates formed by magnesia, when aerated in waters, are the most permanent, and subject to less variations than others ; yet, when the solution was prepared without heat, the phlogiston in the solution gave a yellow hue to the precipitate, which was lost or soon disappeared when it was dephlogisticated by being prepared with heat; yet magnesia constitutes the principal part of the solid contents of the Pouhon water, and it is the only fountain at Spa that contains any of this kind of absorbent earth, as it is the only one that rises from a different elevation from that from whence all the other mineral waters are originated.

- We shall now proceed to the remainder of the precipitants, to discover the second most important part of the medical properties of these mineral waters, from the compleat solution of iron in them by the aerial acid; and close this part of the account with medicinal reflections on this refined composition as a sedative, invigorating, analeptic tonic.

A single drop of the saturated tincture of galls in spirit of wine, gives a purplish hue to all the waters of Spa, but the shade of it will be much the darkest in the Pouhon water; and phlogisticated alkali produces a Prussian blue in them all, but more slowly in some than in others; very quickly, and of a strong colour, in the Pouhon; but in different times, and with different

different degrees of strength and brightness of the colour, in them all.

#### MEDICINAL REFLECTIONS.

The immediate effects of the Spa waters, on the first use of them, are similar to those occasioned by fermented liquors, and in reality arise from the same cause; and if they were, on the first trial of them, to be taken in large quantities, they would bring on real intoxication: every person, on the first use of them, will perceive a degree of giddiness, however cautious he may be in drinking them: but neither common prudence or medical knowledge has yet suggested one necessary caution, in my opinion, which is, that the patients should keep themselves quiet and composed



composed immediately after the first use of them, and perhaps during the whole course of them, and not directly get on horseback, or make use of any strong exertions of either body or mind, as is the usual practice of the place. Every one must have observed how the intoxicating powers of spirituous liquors are aggravated and increased by violent exercise, especially on horseback, as well as by violent agitations of the spirits; a single attendance at a country horse-race will give ample testimonies of these effects, and fatal may be the consequences, as well in some kinds of bodily diseases, as on the passions of the mind, of such dangerous proceedings; yet exercise, when duly regulated, is of great importance in promoting the salutary effects of these waters.

The

The immediate operations of the aerial gas on the sensorium, or the origin of the nerves, will gradually wear away, and new operations take place in the animal system, to remove obstructions and contract and strengthen the nerves.

Custom will render the habit less affected by fermented liquors, till it becomes so debilitated by their poisonous effects, that it will require still stronger forms of them, and a continual supply of them, to maintain its bare existence, till by degrees it loses all its activity, and sinks into an unanimated mass.

The gaseous principle in the Spa waters, after it has lost its intoxicating effects, and is assisted also by their alkaline impregnation, and its sedative, resolving, and detergent ef-

fects in the first passages (so totally different from the acescent principles of fermented liquors) and united also with the strengthening properties of iron intimately combined with it on the general system, will tend to appease the debilitated nervous irritations, and excite new salutary vibrations in the animal fibres, to remove obstructions in the viscera of the abdomen, corroborate the general nervous system, and abate its irregular spasms, and thereby renovate and invigorate, in some degree, all the powers of animal life.

#### THE CHEMICAL ANALYSIS BY EVAPORATION.

The mineral water of the Pouhon fountain has a ferruginous, mildly alkaliescent,

lescent, and spirituous lively taste; to which, in the Geronstere water, though less pungent in taste, must be added the sulphureous taste and smell from hepatic gas. The taste of the Tonnelet fountain is still more pungent and quick on the palate, but discovers its other properties less sensibly.

After all these different mineral waters have been exposed in a broad shallow basin for some time to the open air, a shining pellicle, diversified with a variety of colours, spreads in different proportions over the whole of their surfaces.

Set any of these waters in a sand-heat, or in a warm *balneum mariæ*; before they become warm to the hand, they begin to sparkle and throw up little bubbles, above the surface of the waters, in the vessel that contains them,

as if ready to boil, and the pellicle begins to form; in proportion as the degree of heat increases, the sparkling and boiling appearance increases also in them all, and the substance of the pellicle is thickened and augmented till it breaks into pieces, and then begins to subside to the bottom of the vessel, and the water becomes dirty and turbid.

In proportion as they advance nearer to a boiling heat, the various prismatic colours vanish, the pellicle becomes of a dirty reddish ochreous colour, and a powder, composed of lime or other earthy substances, and iron, begins to subside to the bottom; the waters then have lost all their lively taste, will shew no alterations with the precipitants, and are become nearly insipid.

If you boil any of these waters in a glazed earthen or china vessel, quickly, over a smart fire, they will soon deposite a ferruginous powder: collect this powder by means of a filter, dry it hastily before the fire, and then pour some distilled vinegar upon it in a proper vessel.

The gentle acid will dissolve only some of the earthy substances, and leave the dephlogisticated iron unaffected.—Precipitate the substances that are dissolved in the vinegar by the assistance of an alkali, and on a proper examination of them, by the rules of chemistry, they will be found to be an aerated lime, or some absorbent earth.

In other trials, let the evaporation be continued with less degrees of heat from the beginning, till the whole of the aqueous part shall be evaporated, and  
after

after the appearances already mentioned, on exposing the different waters in a sand-heat, or a gentle *balneum mariæ*, a powder of the colour of ochre has been continually separating, which may be carefully collected from the dry residuum by repeated washings, properly conducted; when this powder is thus obtained by filtration, on pouring distilled vinegar upon it, with which it will gently effervesce, and in the Poulhon water, the greatest part, on a chemical examination of it, will be found to be aerated magnesia. In the Geronstere water, a small part remained untouched, which, on examination, proved to be gypsum, or a variety of selenite; but it did not amount to a twelfth part of the whole residuum. The results of this part of the analysis will be distinctly marked in the general table of

the five principal waters.—In all the residua of the different waters, this precipitated powder, when properly collected, and treated with distilled vinegar, yielded small quantities of different substances, and all still retained some small remains of the dephlogisticated *debris* of the iron.—I then proceeded to the examination of the different washings of the residua, which, treated according to the methods laid down in the Introduction, not necessary to be repeated (and which are formed on the rules directed by the best modern chemists, but particularly by Bergman) all exhibited, on chrysalization, small portions of the mineral alkali, without the mixture of any cubes of common salt, that I could satisfactorily discover, in any of the waters, although I made repeated trials of the  
same



same methods on the residua of every one of these waters. And this alkali, when united with the vitriolic acid, formed a true Glauber salt in each of them : in some of them, some chrystals of a genuine vitriolated vegetable alkali appeared.

Many of the experiments which I made with these waters, during my continuance at Spa, were for purposes foreign to those of a real analysis of them ; but whenever they were appropriated to that view, the strictest attention was paid to the exact quantity of water submitted to the examination, as well as to separation, washings, and collection of the different residua. The quantity of water taken from each fountain, for these experiments, was never less than five pints, but generally amounted to four quarts ;

and the waters were always taken in dry and rather cold days, at which times they are supposed to be in their highest perfection.

As the quantity of water that was taken, to estimate the different proportions of aerial acid contained in these several waters, was a quart, or from 32 to 33 ounces, the exact quantity which filled the glass vessel in the apparatus that was then made use of; in the following table, the solid contents in each water, obtained by evaporation, are proportionally reduced from about two-fifths to one-fourth, in each experiment, according to the quantity of water that was actually submitted to examination, and the results estimated as if obtained from a quart of each water, Winchester measure, or 70.50 cubic inches of water.

The

The whole of the residuum obtained from the Geronstere water, amounted only to about one-third part of the solid contents obtained in the Pouhon fountain, and this quantity was something more than what was obtained from any of the other waters, including in the account the three less-frequented springs, that were not examined, for want of time, with the same scrupulous attention as the five most distinguished fountains: and the quantity obtained in the purest fountain did not amount to one-eighth of the quantity in the Pouhon.

It is worthy of remark, that all the fountains situated on the elevated ground towards the south, and on the opposite side of the town to the source of the Pouhon, contain much less in quantity of their solid contents than

the Pouhon water ; and the higher the fountain was situated, on their elevation, the more contents were found in it on evaporation : and the purest springs were those that were situated towards the bottom of this mountain, and on the smaller elevations.

The same methods of proceeding were taken with all the waters, as were with the Pouhon ; and the treatment of the residua, to obtain the following results, with the exactest sollicitude, was pursued in all.

The Geronstere water yield-		} 5 Gr. 50	
ed, on evaporation in			
70.50 cubic inches	—		
The Sauviniere	— —	3	75
The Groisbeeck	— —	5	25
The Tonnelet, barely	—	2	—

Half

Half of this quantity, one - eighth only of the residuum in the Tonnelet water, was aerated iron ; and of the remaining half, the greatest part was fossil alkali, mixed with a small quantity of calcarious earth, of which a very small proportion might be magnesia.

## The T A B L E.

Fountain.	Quantity of Water.	Solid Contents.	Aerated Lime.	Aerated Magnesia.	Aerated Mineral Alkali.	Aerated Iron.	Selenite.	Aerated Vegetable fixed Alkali.
Pouhon	33 Ounces.	Gr. 16.25	2.75	9.50	2.25	1.75	—	—
Geronstere	32.75	5.50	2.50	—	1.75	0.75	— 50	—
Sauviniere	32.50	3.75	1.50	—	0.75	0.50	—	1.00
Groisbeeck	32.25	5.25	1.50	—	1.00	0.75	—	2.00
Tonnelet	32.	2.00	0.25	—	0.75	1.00	—	—

The quantity of water, by measure, was always the same, as nearly as possible, in making the experiments on each of the mineral waters, notwithstanding their difference in weight. The specific gravity of all these waters is ever variable, in different states of the atmosphere, as taken by the barometer and hygrometer, as well as the thermometer; whether this variation, in all these mineral waters, of their specific gravities, is owing altogether to the different quantities of aerial acid they may be impregnated with at the time they were examined; and whether the number of their principles, and the quantities of them, may not always be the same exactly in every mineral water (which is not improbable, and I have reason, from the number of experiments that I made upon them,

them, to think this to be the real case  
 with them); and if the nature of the  
 principles, of which these waters are  
 chiefly composed, be chemically confi-  
 dered, we can have little doubts of the  
 variations in the principles themselves,  
 as well as of the uncertainty of the  
 quantity of each that may be found in  
 them, in different seasons of the year,  
 and at different times of the same sea-  
 son, and even at different hours of the  
 day. And, from various other experi-  
 ments made on these waters, and which  
 were not included in the number of the  
 exact and accurate ones from whence  
 the foregoing table was formed, and  
 just estimations made of the several  
 contents in the different waters, my  
 experience upon them would fully con-  
 firm such an opinion, and leave suffi-  
 cient room to suppose that some va-  
 riety



riety of selenite, and especially some portion of marine salt, may have been really, at different times, found in some other of these waters, by able chemists, than the single one I have mentioned to contain selenite ; especially when the experiments were not made on the spot ; for I learned, on visiting the different fountains near Malmendy and Stavelot, that the mineral waters from a spring called Bru, or the grand fountain of Chevron, near Stavelot, have been exported some years ago for Pouhon water, and marked as the Pouhon bottles are, to the quantity of a hundred dozen of bottles in a year. The waters of the Bru fountain contain both marine salt and selenite, and of course vitriolic acid in a small quantity. And, on account of the uncertainty of the quantity of each of the ingredients

ingredients in these several waters at different times, the table was formed on the greatest quantity of the different substances I ever obtained from them in the same experiment, and when the waters were in their most perfect state.

The gross imposition on the public, in the exportation of the mineral water of the fountain of Chevron or Bru, for real Pouhon water, makes it necessary to give a short account of some other mineral waters within ten or fifteen miles of Spa, without detaining the reader with any attempts of an accurate analysis of them.—The town of Malmendy, ten miles westerly from Spa, is a pretty village, beautifully situated at the bottom of a mountain, on a clear rapid stream of water running through it; and is celebrated for manufacturing the best leather in Germany,

many, from hides imported from South America; and, though it stands in the ancient forest called the Ardennes, commands, on the adjoining elevated stations, a most enchanting prospect.

The monasteries of Malmendy and Stavelot, about six miles distant from the former, but nearer to Spa, constitute one chapter, and are styled Imperial; the members of which jointly choose an abbot, who, in right of his election, becomes a prince of the Empire, sovereign bishop of the principality of Stavelot, and head of both convents, though his general place of residence is at Stavelot.—The principal fountain in the neighbourhood of Malmendy is called Le Couve, or Couve de Pouhon; and near to it lies a low, slow, ferruginous spring, called The Beversee. To the west of the

town of Malmendy, about a quarter of a mile from it, and so called in the Patois language of the country, is La Sige ; this is a very abundant fountain, sends up large air-bubbles in great profusion, and is a very favourite one with the people of Malmendy. Within a few yards of La Sige, is a plentiful spring of the purest water that I met with in this part of Germany, and which is no heavier than distilled water. About a mile from, and to the south-east of the town, lies another noted medicated fountain, called Geromont.

There are various other mineral fountains in the principality of Stavelot ; but, as they differ from the preceding very little, and are all, I believe, gaseous ferruginous waters, I shall omit taking any particular notice of them, and hasten to the principal fountain

tain of this neighbourhood, within six or seven miles of Stavelot, and to the west of it; but the particular situation of it I cannot readily ascertain, neither could I direct any person how to find it, for, through the impracticability of great part of the way with a wheel carriage, I was obliged to make many circumvolutions, and suffered great distress in getting to the place where is situated the Grande Fontaine, called Chevron, or Bru, Brue, from the adjoining villages, who all contend for the honour of giving it their own names.

It is impossible for any person, the least attentive to these subjects, whatever difficulties he may have in getting to it, not to admire the splendor and magnificence of it, when he is arrived thereat. It rises with rapidity,

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and overflows the ample bafon that is provided for receiving it, though now going to ruin ; in its external appearances it refembles moft the fountains of Tonnelet and Niverfet, near Spa. On pouring it from one glafs to another, it sparkles as briskly as the Pouhon water after it is firft bottled, and covers the glafs all over, both infide and out, with brilliant air-bubbles. It leaves a ftrong acid tafte on the palate ; and fuch is the smartnefs of the tafte, that, at firft tafting it, you are hardly fenfible of the iron. In the open air, in a few hours, it loft all its pungency, became flat and turbid, and was of a temperature about 60 ; and threw up a variegated pellicle, much refembling that of the Tonnelet. With the fyrup of violets it ftruck a deeper crimfon purple than  
that

that water; and with the tincture of turnsole formed a beautiful red; and, however subtile and volatile the acid appeared at first, yet the continuance of it longer in the water indicated some more fixed acid to be in it, for it curdled and decomposed soap, yet it made no change when mixed with milk; with the saturated tincture of galls, and Prussian alkali, it gave evident marks of its iron; and with the solution of mercury in the nitrous acid, prepared without heat, it deposited a white precipitate, that soon became of a lemon colour, and gradually of a deeper yellow; with nitrated silver it gave some small traces of a marine acid, which more eagerly unites with silver than the vitriolic acid, and which decomposed the soap, and formed a very small portion of gypsum.—

From this superficial trial of the Chevron water, it will evidently appear in what respects it is similar to the Pouhon water, and with what plausibility it was exported for the genuine water of Spa ; and, though an able chemist may readily discover, by distinguishing tests, a difference between these two waters, yet these marks have, at different times, been said by the best chemists to be found in the Pouhon water ; and ought not to have been the grounds of so severe a censure of them from the body of physicians of Liege, near a century ago : unfortunately for their credit, their reprobation of the Chevron fountain, and their attempts to exalt the superior qualities of the Pouhon above it, are founded on a perfect ignorance of the real composition of both these waters.

Some



Some other motives must have actuated them than the welfare and good of mankind, so benevolently held forth : Spa belongs to the bishopric of Liege ; and better reasons ought to have been given, by a body of learned men, for condemning a mineral fountain in the principality of Stavelot, than that the solution of iron in the Chevron fountain was a fixed acrid vitriolic salt, whereas in the Pouhon it was a mild salt of iron : or, that the abundance of sulphur in the Pouhon (which does not exist in it at all) would moderate and restrain the activity of the acid ; the want of which in the Chevron fountain would render the use of the water dangerous in many disorders, and the corrosive acid, unguarded with sulphur, would be prejudicial in all.

The analysis of these waters, here-

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in faithfully related, and the principles from thence deduced to be really existing in them, may direct and regulate the choice physicians shall make of them, and point out when it may be necessary to interpose the use of more than one at the same time. In the infinite variety of nervous affections, the most active and spirituous ones may be preferred ; when the action of iron, united with absorbents, is only required, the most charged and less spirituous one may be deemed most proper. The volatile aerial acid, in these and all other gaseous waters, gives to their principles their most active powers ; and in whatever degree hepatic air may also be combined in the Geronstere water, it may give it some additional powers in the opinion of a judicious physician, and  
 he

he may use his own discretion in directing his patients to it.

The sentiments of different authors, how the aerial acid, so abundant in Spa water, is extricated out of the different substances with which it was combined in the bowels of the earth, are much divided: all the waters at Spa possess much more of it than they could obtain from the atmospherical air; such mineral waters as contain but little more of this acid than all common water does, may be readily furnished with additional quantities in passing through strata of aerated lime, which are found in various parts of the earth. Three different modes are generally described by authors, how this aerial acid may be extricated, and in great quantities: 1st. By fermentation; but this cannot

be admitted to take place in the earth, at least with sufficient quantities of fermenting bodies to supply such infinite demands. 2dly. By subterraneous fires: these, if admissible in the theory of the earth, would expel great quantities of aerial acid from calcareous and magnesian earths; and water would absorb great quantities of the acid, when more exposed to receive it, by being divided into many passages, through the internal parts of the earth, in proportion to the degrees of its coldness, and the degrees of its compressure enforced by this subtle elastic fluid; degrees of compressure which art can seldom effect. And lastly, By the action of a more powerful acid: for, although water on the surface rarely contains any uncombined mineral acid, yet some  
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of them must necessarily be set at liberty in the bowels of the earth, by a variety of causes ; the deflagration of sulphur and burning pyrites will detach the vitriolic in great abundance ; and the marine acid will be set free from magnesia and salited lime, through subterraneous heat and fires, admitting the reality of such fires in large bodies.

But in the instance of the waters of Spa, this last, and the second cause, cannot readily be supposed to take place immediately, as they possess so small a quantity of saline bodies, and those which they do possess will, from the very nature of them, require a union of aerial acid, previously set at liberty by substances foreign to themselves and externally of them ; for as it appears by the table that they generally

rally contain only mineral alkali, lime, magnesia, and iron, as in the Pouhon and the Tonnelet fountain, and which last contains the greatest share of aerial acid, and which substances are all aerated: it must be clear that these waters cannot be aerated by the saturations of vitriolic or marine acids, and their subsequent decompositions and extrications of the acid, or by the decomposition of some middle salts to distinguish such salts from pure neutral salts, the union of pure alkalies and acids.

There have been many volcanos in the neighbourhood of Spa, and along the course of the Rhine, through all these parts of Germany, though few vestiges of them remain at present, and are hardly discernible, they are so defaced by the lapse of ages.

The admission of subterranean fires  
in

in smaller quantities than to produce earthquakes, or any other violent commotions, is more readily granted ; provided only that the supposed causes are so attemperated in their effects as to remain the same efficient agents in the production of them.

Neither is it necessary that such efficient causes should always be very near to the places from whence the waters issue ; for the cavities and perforations through the superficial strata of the earth are so numerous and diversified, in such a variety of directions, that the supplies of such an elastic fluid may come from very remote distances ; and the circumstance of the water having deposited all its heat, will serve to confirm the opinion, that the air has passed through a very long course from its first extrication.

If

If martial vitriol only is dissolved in water, and you should suppose this water to pass through strata composed of either mild alkaline salts, lime, or magnesia, it may, by decomposing these substances, set at liberty great quantities of aerial acid, which may be conducted to very remote distances, and be there combined with water; which water shall exhibit, besides its aerial acid, only slight impregnations of those original substances, from whose decomposition such abundance of this permanent elastic gas was originally extricated.

Bergman says he has sometimes found a small portion of gypsum in Spa water. In Sweden he could be supplied with only the Pouhon water, supposing that he always had the genuine Pouhon water when he did find  
the



the gypfum, and that he never got any of the fupposititious Pouhon, or the mineral water of the Chevron fountain, near Stavelot; and which water entirely decomposes soap, though in other respects it refembles the Pouhon water; in the livelinefs and brisknefs in its tafte, as well as in its alkaline nature, and the quantity of its iron. Yet he feems to be at fome lofs to explain how this could happen; for he fays alfo, that moft commonly gypfum did not appear in the water of Spa; unlefs, as he really fays, the water in which it appeared was taken from fome other fountain; and he doubts, moreover, whether the number of principles be always the fame in the fame water. Had Bergman made his experiments at Spa, he could not have doubted of their variation: and he moreover ftill  
fays,

says, that he is confirmed in the opinion by experience, as well as the nature of the thing itself, that the proportion of the ingredients in the water must frequently vary.

He expresses his difficulty of knowing how this could happen in this manner, if we suppose a disengaged mineral alkali (or an alkali only united with aerial acid) to be present, as such an alkali attracts the vitriolic acid more powerfully than the lime does ; Whence then comes the selenite ? And he resolves the cause of the gypsum, if really present in the Pouhon, being seldom found in it, and, when found, to be only in very small quantities, by the inactivity of the aerated mineral alkali, by shewing that the combination of mineral alkali with aerial acid is never spontaneously decomposed ;

composed ; and that substances which are so thinly dispersed through the water, must act very slowly upon each other : and explains also how the activity of substances is repressed by being united with aerial acid, in the instance of vitriolated magnesia dissolved in water :—Drop a little of this solution into lime-water, and the magnesia instantly drops to the bottom of the vessel, having yielded its acid to the lime : but if pieces of chalk or calcarious spar are put into the solution, no decomposition can be produced even by boiling : and vitriolated magnesia does really exist in Seydschutz water, together with aerated lime.

It is humbly hoped, that the learned and judicious physician, who has never visited these fountains at Spa, from this concise but faithful examination of their  
waters

waters on the spot, will be able to estimate the medicinal qualities of each of them, and of the excellent water of the Pouhon in chief, as a mild but active and powerful tonic ; and be enabled to interpose the use of any other of these justly-celebrated springs, or direct his patients to any one of them in particular, as his knowledge of their constitutions, and the several disorders they may labour under, may suggest to his wisdom and penetration, for the general benefit of mankind, and the credit and honour of his profession.

T H E  
ANALYSIS of the MINERAL WATERS  
O F  
A I X - L A - C H A P P E L L E ,  
A N D T H E E N V I R O N S .

**I**F, under the denomination of sulphureous water, we should include only such waters as contain real mineral sulphur, as it is found native in a great number of places, or prepared by art from pyrites, this class of mineral waters would be reduced to the smallest of all the classes: and the best chemists have determined, by real experiment, that the sulphur which is united with iron and argillaceous earths in the pyrites, is an imperfect one; and

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many of these experiments were made on pyrites that contained neither arsenic or copper.

From hot sulphurated waters, an hepatic vapour is easily collected, whose presence is discovered by its peculiar smell; and when this is present, united with aerial acid disengaged, it will be decomposed by pure air on its quitting the water: the hepatic aura is very tenacious of its vaporous form; yet, when large and dry surfaces are exposed to the atmosphere, the pure air in common air will attract the phlogiston, which, as long as it maintained its vaporous form, was the bond of union of the sulphur with the matter of heat; when this union is dissolved by pure air, the sulphur will appear in its proper form, and from hence are formed all those masses of real mineral sulphur, found in the arches of the fountains,

tains, and of the aqueducts to carry off the waste water from the fountains at Aix-la-Chappelle ; for the hepatic vapour is really decomposed whenever any substance is united with it, that will attract and separate its phlogiston.

Real sulphur and water can never be united together, without the intervention of another substance ; and this union of an intermediate substance with sulphur forms, in the language of chemistry, the *hepar* or liver of sulphur. This intermediate substance is either pure alkali, or some alkaline absorbent earth, most frequently the calcareous earth. The defect of real sulphur in a state of union with many mineral waters, that are generally styled sulphureous ones, is not occasioned by those waters containing in them no substances that are proper to form such a

SCIENCE T 2 union

union by the intervention of them, as in the hepars; for many of them contain fossil alkali and absorbent earths, held in solution: yet nothing is more uncommon to be found in these waters than any true hepar, according to the opinion of good chemists; for if you add to these waters a small quantity of any genuine hepar, a few drops of a concentrated mineral acid will precipitate real sulphur, not readily discoverable in them before.

To suppose that the solution of these alkaline substances, in so large bodies of water, prevents their acting with sufficient powers to be combined with the sulphur, and form an hepar, will not be deemed a clear explanation of this imaginary difficulty; nor will the assertion that the degree of heat in such waters is not adequate to produce the union, be deemed more satisfactory, since

6
there



there are many cold mineral waters that have the same hepatic smell.

A physician from Leyden, some few years ago, who had resided several weeks at Aix-la-Chappelle, for the purposes of making experiments on the waters, related to some of the faculty of the city, that a solution of arsenic in the marine acid would exhibit a precipitate of genuine sulphur, that was dissolved in the water at Aix, and kept suspended in it by the means of fixed air.

A good chemist would deem this experiment to be highly problematical; for the precipitate might be formed by elective attraction from the arsenic, on the marine acid uniting with the absorbent earth, and form a marine salt with an earthy base; or with fossil alkali, and form a true marine salt.

And

And though the precipitate is related to be found, after some days, covered over with a substance of a yellow colour, this would not prove it to be real sulphur, any more than the yellow precipitate in the Spa waters, procured with the solution of mercury in the nitrous acid, prepared without heat, would lead you to suspect that those waters contained also sulphur; which was never supposed but by the college of physicians at Liege, a century ago; and in the record which I saw of this fact, it is not mentioned which of the three kinds of arsenic the waters had been treated with, and two of them are prepared with real mineral sulphur.

Many chemical authors have imagined a certain affinity and mutual predilection between arsenic and sulphur, and from its property of mineralizing  
 metallic

metallic bodies, supposed it to be a real sulphur; yet, though the regulus of arsenic, as well as orpiment and realgal, are capable of inflammation, pure white arsenic is not; and it must be clear from these appearances, that its sulphureous properties are admissible only in some certain circumstances. Zinc and other metallic bodies are inflammable, which can by no means from thence be called sulphurs, except merely to indicate thereby the great quantities of phlogiston they may contain, and properly combined to have this effect; and the same may be said of inflammable air, and from thence many suppose it to be the same as hepatic air. Mr. Scheele of Sweden first elucidated the distinct properties of the acid of arsenic, and established the true nature of it by the most decisive experiments.

Mr. Macquer, in his report to the *Academie Royale des Sciences* at Paris, concerning the mineral waters of Montmorency, observes, that these waters precipitated solutions of metallic substances in a mineral acid, in the same manner as real hepars would have done ; but that with the acid alone no precipitate whatever was found : and he observed also, that as soon as the precipitate was formed by the metallic solutions, the smell of the hepatic air was lost ; this he attributes to the air attaching itself to the metallic substances, and thereby losing its volatility.

From the results of several of his experiments on these waters, he was at first induced to believe that the sulphureous waters of Montmorency contained real sulphur in them ; but, on a further critical examination of them  
afterwards,

afterwards, by other methods of trial, he never could obtain any real sulphur from the waters themselves in their natural state; yet at the same time he cautions against arranging these particular waters under the same class with those which contain only the vapour of sulphur, which is more properly called hepatic air, arising from the hepars of sulphur, and whose nature is so fully explained by Bergman.

The reason why Mr. Macquer was unwilling to arrange those sulphureous waters, that contain only hepatic air, in the same class with those of Montmorency, was this, that, had all these kinds of waters been arranged under the same denomination, it would have been necessary that none of them should have contained any salt, combined with a vitriolic acid, which would be required

ed to establish the fact of the real decomposition of the sulphur.

So much has been already said in the Introduction on this copious subject, that I am in danger of repeating the same observations; but if I should be so happy as to place them in a different point of view, my readers, who are not much conversant with a subject in many respects not very familiar to any, and which is also of so subtle and intricate a nature, may pardon the offence.

The hot hepatifated waters may be also *aerated*, as will manifestly appear in these mineral waters of Aix-la-Chapelle, and may be readily distinguished from plain, hot, aerated waters, such as are the waters of Plombieres, united with hepatic air, as well by the general tenor of their characters, as by their disagreeable

agreeable smell.—All the waters in the city of Aix-la-Chappelle have the smell of the hepars. Every stranger that comes to visit the city of Aken and its baths, must, on his first approach to any of the springs, be sensibly struck with the smell which arises from them all; but, on entering into any of the rooms where the waters are kept, especially after they have been emptied, cleaned, and filled again with the waters fresh from their sources, the smell of them must be highly ungrateful and disgusting to him. They will all blacken silver and other white metallic bodies, as will the vapours arising from a variety of other substances, in fermentation or putrefaction; and a genuine sulphur is deposited in great masses on the stone roofs that cover the wells, as well as on the inside of the  
arched

arched aqueducts that convey the waste water from the greater sources; and will be found actually deposited in the mud and other substances at the bottoms of the aqueducts.

And yet the most accurate analysis had not hitherto been able to discover in the water the most minute particle either of the hepar or of sulphur: but Mr. Bergman thinks he has unfolded the mystery in this manner, by relating that every hepar sulphuris, upon adding to it some drops of a more powerful acid, generates a species of air, which he, as well as Dr. Watson, calls hepatic air, if every permanent elastic fluid, not condensed by cold, may be called an air.

And this powerful acid he found in a highly concentrated nitrous acid, *Hoc nempe acidum*, says Bergman, *phlogiston*



*phlogiston arripiendo, sulphur, ejus ope materiæ caloris adunatum, deturbat, quamvis consuetas explorandi methodos omnino eludat: acidum nitri concentratum, justâ instillatum dosi, mox fætorem tollit, quod decompositionem certò indicat, sulphur tamen subtilissimè divisum lentè subsidet.*

And the subsidence of it was indeed so very slow, that I never had the happiness to see it, in either the Geronstere water at Spa, or in the sulphureous waters at Aix-la-Chappelle, although I had furnished myself, before I left England, with the best concentrated nitrous acid, from the excellent practical laboratory of Mr. Willis, chemist, at Hermitage wharf, Wapping. Any water, he says, impregnated with this kind of air, resembles the hot hepatifated waters: hepatic air contains true sulphur, *sed ita subtilisatum, ita expansum, ut visum fugiat,*

*fugiat*, and puts on the appearance of common air.—That it contains real sulphur, however modified and subtilized, I am firmly persuaded, although I did not happily obtain a sight of it deposited in substance from either of these waters; yet, till more efficacious methods can be devised of finding it in an expeditious manner, the concentrated acid produces no other effects on the water than common air, by the pure air contained in it, will have on the vapour when it has escaped from the water, and the aerial acid has also escaped, and real sulphur is formed by sublimation on the arched roofs of the aqueducts; neither will the discovery be of so great importance as he boasts of, in the analysis of mineral waters that may be justly called sulphureous, either hot or cold, if the detection

of

of the sulphur in them is so readily accomplished by the common operations of nature.

When artificial hepatifated waters are made, by being impregnated with this hepatic air, and as fully combined with aerial acid as many of these waters are ; how far an immediate deposition of the sulphur thus given to the water, may be obtained by a proper quantity of a concentrated nitrous acid, I cannot pretend to say, as I have not made a compleat set of experiments with that view ; but, after the many repeated and unsuccessful trials of nitrous acid, with the Geronstere water at Spa, I should have been almost as much surprized to have seen it really subside in the waters of Aix-la-Chappelle, as a rascal of an alchemist would have been on discovering a true transmutation of the

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metal,

metal, when he had not previously and secretly conveyed some real gold into the crucible.

It is well known, by every person versed in chemical experiments, that the hepars of sulphur are liable to decomposition, but with different degrees of celerity, in proportion as they are diffused in different quantities of water, and exposed to different degrees of heat: and the hepars made with lime decompose sooner than any of the others. And it is reasonable to suppose, that in the original formation of sulphur, either native in the bowels of the earth, or especially in the artificial manufactories of it, that the sulphur shall seldom be formed pure and uncombined with other substances, and that it frequently attaches to itself some fuliginous matter of an asphaltous nature,

and

and which will adhere strictly to it, remaining firmly united with the intervening substance after the sulphur shall be decomposed; and, if this combination be exposed to moderate degrees of heat, till nothing shall remain in it but the asphaltous substance and the fixed alkali, yet this combined substance will retain the smell of the hepar, and affect the organ of smell in the same manner as genuine sulphur, or the hepatic air, and the vapour that arises while it is over the fire will turn all white metallic bodies of a blackish colour.

After having advanced thus much relating to the hepars of sulphur, if I might be at liberty to form any conjectures how these appearances relating to sulphureous mineral waters take place in the physical world, I should venture to advance the opinion, that in all such

U combinations

combinations of a mineral or absorbent alkali with aerial acid in the sulphureous water, and united with phlogiston in different proportions, the hepars, if there are any really in them, would be immediately decomposed on their issuing into the open air; the phlogiston be gradually dissipated, and attracted by the pure air, always existing in common air; and the acid, still retaining the hepatic smell, alone remain in the water, having united with, and in some degree or other aerated the alkaline substances held by it in solution in the water.

In such hepatic waters the decomposition will be accelerated by the dissipation of the phlogiston; by the same means the hepatic smell may arise from the fermentation and putrefaction of vegetable and animal bodies; and the

6. *Acid vapour*

vapour from both will discolour metallic bodies.

This hepatic air, though not volatile in any very great degree, is permanently elastic, and cannot be concentrated in a less volume of the water; and this phlogistic vapour, when it is detached from the acid, enjoys to the taste and smell all the properties of them both when in a combined state, though, when the hepatic air is entirely detached, no real sulphur does or can exist in the water.

No regular processes were undertaken at Aix-la-Chapelle, or the environs, to estimate the exact and comparative proportions of fixed air in the different springs, as well on account of the great length of time it would have required to have done it with precision in such a number of them, as the little

necessity that appeared for instituting them, for in the trials that were made none of them appeared to contain more than 24 ounce measures of fixed air, in 70.50 cubic inches of the water, the same as was collected from the Geronstere water at Spa.—Bergman has estimated the quantity of hepatic air in the waters of Aix-la-Chapelle, which he had never visited, in the proportion of 13.068 grains to a pint, Winchester, or 35.25 cubic inches, and puts the real sulphur in them to be in the same quantity of water at 1 grain, 7424.

All the mineral waters of this class are as capable of being chemically analysed by evaporation, in order to collect their principles or solid contents, as any other mineral water, and the same precipitants may be employed as were made use of with the Spa waters.

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The sense of smell seems alone capable of ascertaining the quantity of hepatic gas united with the fixed air, in these, or indeed in any of these gaseous sulphureous waters. And the modes of ascertaining the quantity of real sulphur, contained in any of them, must be equally equivocal and fallacious.

All these waters, on exposure for a time to the open air, lose intirely their peculiar smell, and that in a quicker manner, or more slowly, as they are exposed to greater or less degrees of heat; and if, on exposing these kinds of waters to the open air, or to distillation, they really contain no other kinds of substances, they then become in no degree different from common water. It may be necessary to remark, that the mineral waters of Aix

suffer very little or no change in them, from the different states of the atmosphere, as was manifestly the case with all the different fountains at Spa; whether this may arise from the close coverings of all the sources of these waters I cannot determine; and I had not time to observe, whether, in the open fountains of the adjoining village, such alterations in different seasons really took place; but this probably is the case in all gaseous springs.

Although the fact, that certain substances, when mixed together and exposed to the open air, should a sufficient quantity of water from rain, or any accidental cause, be united with them, will frequently grow hot, even to bursting out into a real flame, must have been observed by many curious inquirers into natural appearances; yet  
the

the illustration of this supposed origin of subterraneous fires and volcanos, by actual experiment, is due to the industry and sagacity of Lemery. By forming equal quantities of powdered sulphur and iron filings, with a sufficient quantity of water, into a paste, and putting this composition in an iron pot, inverted, and buried a foot or more under the surface of the earth; in a few hours the earth grew warm, and heaved; hot sulphureous vapours issued through the fissures in the ground, till a motion was perceived in the earth, and actual fire burst forth, with the effects of a real earthquake, producing a volcano on a small scale, by the reciprocal action of iron, sulphur, and water.

Many other compositions of the same materials, mixed with various

other substances, will produce similar effects ; and the explanation of the chemical causes of these appearances will tend to illustrate this otherwise obscure fact, if true, though other phænomena may lead to the confirmation of it, that the matter of heat is the real union of vital air with a determined quantity of phlogiston. This was the opinion of Mr. Scheele, and from him adopted by Bergman, till he afterwards retracted it ; as were many of the most valuable discoveries of Scheele ; and he is at all times ready to acknowledge his extraordinary acumen and sagacity in matters of chemistry. Modern chemistry makes two distinct substances of the matter of heat, and phlogiston ; in the room of the latter, as thinking it unnecessary, Mr. Lavoisier has substituted pure air to answer all its purposes.

Iron,

Iron, soaked for a length of time in water, forms a martial calx or æthiops on its surface; with bare humidity, a rust. Sulphur in water lies inert. Mix the iron and sulphur together, no action will take place, till the addition of water shall communicate a moisture to them: granting then, as the fact is certain, though the mode of action may be unknown, that the water expels the phlogiston from the iron, the sulphur will then attract the iron despoiled of part of its phlogiston, and thereby promote a farther discharge of it: by this mutual action on each other, the phlogiston will be exposed on every particle of the metallic calx to action, and attract the vital part, or pure air, from the common air, till this united body grows warmer in proportion to the quantity of  
 pure

pure air imbibed, till it sets the sulphur into combustion; and by these means all the foregoing appearances and effects take place, in proportion to the quantity of the accumulated materials.

From the lavas thrown up by different volcanos, it is evident that martial and other vitriols, aluminous and gypseous substances, as well as a variety of other combinations with calcareous, argillaceous, and siliceous earths, are generated in them in immense quantities; and these saline bodies, mixing with the other bodies, and agitated by the violence of the combustion, will separate and pour forth in great abundance all the different gaseous auras, to be propagated and dispersed through the infinite cavernous and perforated cavities, in every possible

fible direction, under the superficial coverings of the globe, for ages to come; and, though no volcanic mountains at present appear in these countries, yet the evidences of their former existence, in a variety of places, are incontestible. And hepatic, as well as fixed and other airs, may be intimately combined with the various waters existing in the bowels of the earth, till, on issuing into the open air, the phlogiston may be again united with pure air and acids, again forming the concrete mass of real and genuine sulphur; not to insist in this place, on what has been so often mentioned before, especially in the Introduction, the various other modes from whence different waters may be impregnated with hepatic air.

Here it may be right to notice an  
 observation

observation on the Geronstere water, that was omitted in its proper place : It has been observed in the Introduction, that some waters, in which were contained portions of rotten wood, had been found to be impregnated with the smell and taste of other hepatic waters ; now, immediately on the higher ground, above the Geronstere fountain, was found a large extensive morassy swamp, surrounded with many old pollard trees ; and this *fange*, as they call it in the country, was filled with thick muddy water, containing many decayed vegetables, branches of the neighbouring trees, with various other substances, so as to render it safe to stand upon it in many parts.

The imperial city of Aken, or Aix-la-Chappelle, stands in an open plain, surrounded with various rising hills, at moderate



moderate distances, one of which, called Loufberg, is to the north of the city, and very near to it; on ascending it, a pleasing prospect of the whole city and its territory is to be obtained.

The city is amply furnished with fresh water; and, from the numerous devastations it has sustained by fires, in different centuries, great attention has been paid to prevent such disasters for the future: the first resource is by a small rivulet, conveyed from the hills on the south-west side, in an open aqueduct, into and through the city, in which it turns various mills, and serves for the uses of breweries, fullers, dyers, tanners, &c. and may be occasionally stopped in its course, and conveyed into reservoirs for extinguishing fires, and other useful purposes.

The second supply is derived from sources southward of the former; this is a much lighter and simpler water than the preceding one, and more useful in all the purposes of common life. —But the best and purest water in the city is derived from a source within the territory of it, to the north-west, within the distance of about two English miles; it is called the *Seffen*, and is one of the purest waters I ever examined.

Every stranger who shall visit these fountains, must be wonderfully struck with the immense quantities of water daily issuing from them, and which have been celebrated through so many centuries for their thermal medicinal qualities, as well as their disagreeable odour.

There are many sources in this city  
of

of these mineral waters, not necessary to be distinctly enumerated, which are all naturally hot, but not of equal degrees of temperature, even in their original sources; but the degrees of heat are still more variable in the different baths that are derived from some of the sources, from their situations, sizes, and greater or less remote situations from the principal original source; for many of them come from more than one of these primary sources.

The principal source, called Cæsar's, or the Emperor's Bath, from Charlemagne, rises almost in the center of the city, in a declining situation, east of the town-house, and to the north of the great church, where the relics of Charles the Great are preserved with great veneration.

From the depth and volume of the  
water

water in this principal source, as well as its being closely covered with a large grit-stone from Normandy, and confined by iron-bars with different locks, the keys of which are kept by the principal magistrates of the city, it is impossible to form any opinion of the manner in which it rises up into the source; yet, from the comparison of it with the less important springs, and the nature of its composition, it is reasonable to suppose that it springs up with a considerable quantity of aerial gas, accompanied with a sparkling appearance and bubbling noise.

And when we consider the number of aqueducts to carry off the superabundance of water—and the number of baths which it supplies in different houses, some of which are very large and commodious—and the consumption

tion of waste water that runs from all these baths through the streets, to serve the purposes of washing linen, and other uses; it appears impossible to ascertain the quantity of water which the different sources daily supply.

In all the bathing houses there are accommodations of all kinds and sorts. 1st. Common hot baths, that will hold from one single person to ten or twenty, in whatever posture or situation they may require. 2d. Vapour baths, in which the whole body also, except the head, or any part of it, may be included, and exposed to the warm vapours of these waters, in their natural state, or easily raised to any degree of heat that may be thought proper. 3d. Pumps, which are so constructed, that one or more columns of water, of greater or less dimensions also, may

fall on the whole body, or any particular part, and from different heights, or in different directions.

4thly. Most of the bathing houses are provided with dressing-rooms, with or without beds, and all of them with beds to lie in, to sweat or to cool after the use of any of the baths, as well as dry hot rooms; and they have all apartments for lodgings, properly provided, and many of them are neatly and elegantly furnished.

At the fountain, as it is called, which is situated with a pump in an open spacious cloyster, and so named in particular to distinguish it from the other sources made use of for bathing, or to which the strangers resort to drink the waters; at this fountain, the pump of which is at some distance from the covered source from whence it is raised,  
the

the taste and smell of the mineral waters are less disagreeable and offensive, than when taken from the more close and confined springs.

It is difficult to describe and ascertain the peculiar taste of these waters; and this want of precision in their taste will lead the strangers, on their first arrival, to compare it to a variety of offensive tastes, as their own feelings shall direct them to whatever gives them particular disgust; but habit and custom in the use of them wonderfully lessens this disagreeable taste, and, in a short time, it will become so far familiar, as not to appear at all nauseous to them.

The temperature of the heat in the several sources of these waters, is somewhat different in all of them; but I found a very trifling variation in the

standard heat of each fountain, through the different states of the atmosphere.

At the Emperor's bath, in the water raised by the conducting pipes from near the bottom of the well, Fahrenheit's thermometer stood at	- -	136
In the water issuing from the waste pipe at the top, at only		128
From the well at the new bath		133
In a source or well common to two baths, and St. Quirinus's		120
In that of St. Cornelius	~ -	115½
In the Rose bath	- - -	115
In the basin at the fountain, where the water is received for the drinkers	- - -	112
But in the covered source, from whence the water is raised and conveyed		



conveyed thro' wooden pipes  
to the fountain, to above - - 134

# WITH THE PRECIPITANTS.

1. With the saturated tincture of galls, as well as with the fine powder of them, in none of these hot medicinal waters, either in their natural state, or when they had been kept in a vessel perfectly closed up twenty-four hours, and became quite cold, any other change whatever appeared in them, than that they became muddy and tinged with the proper colour of the galls.

2. With the phlogisticated alkali, no other change whatever happened, with the water in both the same states, than in rendering them, after standing

together some time, tinged, and slightly too, with the palest shade of green; not the least trace of a Prussian blue.

On adding a single drop of vitriolated iron, to a pint of the water taken from the waste pipe at the Emperor's bath, both the saturated tincture, and the phlogisticated alkali, gave evident testimonies of the presence of this small quantity of iron contained in a single drop of the solution.

3. With the tincture of turnsole, or a solution of lacmoss, each of the waters, when taken fresh from the source, turned the blue colour of it to a bright purple, but less of the rose red than the waters at Spa; but on letting the water stand till the aerial acid had escaped, this colour faded away, and the mixture became of a blue colour, the same as the pigment.

4. With

4. With syrup of violets, the least certain test of alkali, none of these waters immediately made a change in the colour of the syrup ; but with half an ounce of it, added to two ounces of the thermal waters hot from their sources, they became in two minutes of a sea-green colour, which gradually assumed a brighter hue ; with the water when cold, the change was slower, and the colour muddy and less bright.

The concentrated acids all occasioned considerable ebullitions, but no deposit was formed from the waters with any one of them.

5. Salited terra ponderosa discovered not the least trace of a vitriolic acid being contained in these waters, by forming with it any appearance of a spathum ponderosum.

6. Nitrated silver gave evident marks

X 4 of

of a marine acid in these waters, by its immediate seizure of the silver, which subsided gradually in the waters like a mucilage.

7. Nitrated mercury, made without heat, discovered also the marine acid; and when prepared with heat, and was thereby dephlogisticated, the precipitate with the aerated mineral alkali was at first yellow, yet soon became whitish.

8. Acetated lead formed a white powder with them.

9. Alum deposited its earth.

10. The acid of sugar precipitated part of the lime.

11. With soap they formed a tolerably equable solution, but not uniformly so as with the waters of Spa; and, a single drop of vitriolic acid being added to a pint of the solution, it immediately

diately curdled, and became in time perfectly decomposed.

12. With milk, on boiling, they formed no coagulation.

#### MEDICINAL REFLECTIONS.

Hot hepatifated gaseous mineral waters, in which are combined, in a large portion, the aerated mineral alkali, united with nearly equal quantities of an aerated lime and marine salt, without any styptic or astringent ingredients in them, will hold out to a medical mind, well stored with judicious observations, and minute investigations of the rise, progress, and terminations of a variety of human diseases, under so happy a composition, a useful, gentle, purgative and diuretic medicine;

medicine; and absorbent at the same time, in the relief of acidities, and other consequences of originally weak or impaired powers of digestion; invigorated with the active gaseous acid, and stimulating effects of the hepatic air, in the assistance of their attenuating, dissolving, and detergent effects: but if he extends his views to their various uses as tepid or hot baths, the effects of them in the humid or hot dry vapours, in relaxing contractions of the limbs, indurations of the ligaments, and other ill consequences of diseases or external injuries from wounds, bruises, and various other causes, and in the relief of irregular nervous spasms and convulsions, or their stimulating and corroborant effects by the different modes of the external application of them, as well as their  
cleaning

cleansing and healing effects in various diseases and deformities of the skin, and cutaneous membranes ; he will think them highly deserving of his attention, when judiciously managed, and not forget any of the ill consequences that must ever attend the improper use of so powerful remedies in very weak habits, as well as in hot feverish constitutions, subject to inflammations of the lungs and hæmoptoes, as well as to erysipelasses and inflammations of the cutaneous and cellular membranes.

In cold scorbutic and chronic rheumatisms they must claim his attention ; and, situated as they are, he may find reason to deem them a most excellent preparative for the use of the strengthening, corroborant neighbouring waters of Spa, in a variety of cases, where the union of both these waters in succession

cession may be attended with the most lasting and beneficial effects.

#### BY EVAPORATION.

Though the mineral waters of Aix-la-Chappelle have so singular a disagreeable taste, which is also strongly alkalescent, yet the most nauseous part of the taste and the smell entirely vanishes in a short time, on exposing them to the open air; the smell may be again restored, for a short continuance, by heating them afresh; but after it has been once restored to them by heat, it can never be afterwards revived; and if, on their first exposure, they have remained a long time in the open air, the revivification of the smell will never be obtained.



Set a glafs of thefe waters, taken fresh from the Emperor's bath, in a sand-heat or a warm balneum mariæ, and though the water appears, at first taking, clear, bright, and pellucid, it will very soon part with its strong disagreeable smell, and a pellicle then begins to appear on the surface, formed from the lime, and increases in proportion as the aerial acid is more or less diffipated by the different degrees of heat in the sand-heat or the water bath : this pellicle does not appear variegated with a variety of colours, as in the ferruginous waters of Spa, but assumes a dusky whitish hue ; and a similar appearance, of the same colour, shews itself in the body of the water, as if some earthy substance was precipitating, that was held in solution by the acid before it was dispersed from the water.

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On

On exposing these waters to a sufficient degree of heat to continue the evaporation, in the same gentle manner as was practised before, in the analysis of the Spa waters, and continued to dryness, the whole of the residuum that may be collected, after the evaporation of 70.50 cubic inches of these different mineral waters, will amount to some quantity, from 46 to 58 grains ; and in most of the waters the residuum was gritty, with various appearances like little scales, which had a saline taste, and were all of a whitish colour from most of the noted springs ; for I cannot say that the trial by evaporation was extended to them all.

When these residua were collected, washed, and weighed, as in the process with the waters at Spa, they were afterwards treated with alcohol, cold distil-

led

led water, and boiling water, and afterwards filtrated ; the remaining parts of the residua, not soluble in either alcohol or water of different degrees of temperatures, were then treated with vinegar ; the acetous solution, after the treatment of it, and the aerated lime collected, was afterwards evaporated to dryness, and then further treated with a diluted vitriolic acid, but no felenite appeared in it, nor vitriolated magnesia ; and the part not soluble in the vinegar was so extremely small, that it could be hardly estimated : the different washings were next treated in a manner agreeable to the rules of chemistry. It then appeared, from the results of all the different treatments of the several parts of the residuum obtained from 70.50 cubic inches of the water taken at the  
Emperor's

Emperor's bath, and raised from the bottom of the source, that 58.50 grains of the residuum were collected, and then properly treated, there appeared,

Of aerated Lime,	Aerated Mi- neral Alkali,	Salited Mine- ral Alkali,
14.50 Gr.	30.75.	13.25.

On the examination of the other mineral sources by evaporation, the same modes of treatment were instituted, though not with equal accuracy, as in the water from the Emperor's bath, and no essential difference was found in any of them, with regard to their solid contents, except in some small variations in the quantities of the same substances.

The

The varieties in the different degrees of heat in the several sources, have been already noticed; and no attempts were made to ascertain the different proportions of the fixed air contained in the several waters, as, on the few trials that were made with some of them, the quantity obtained, in none exceeded 24 ounce measures in 70.50 cubic inches of water, which was nearly the quantity collected from the Geronstere water at Spa.

It can hardly be worthy of notice, that the least quantity of residuum, though not in any considerable variation, was collected from the source of the fountain where the waters are taken internally.

THE  
W A T E R S  
OF  
BORDSCHEIT, or BORSET.

**B**ORDSCHEIT is now a considerable village, within less than a measured mile of Aken, with a church and a convent of nuns; and the feignery of the place is vested in the lady abbess of the convent, who generally appoints one of the burgomasters of Aken her administrator. It is a manufacturing town of cloth-workers, who are induced, by the great abundance of naturally hot lixivial water, so necessary  
in

in their manufactory, to make it the place of their residence.

There are two fets of thermal waters at Borset, called the upper and lower hot-springs; the upper baths spring through the fissures of a gritty rock, at the bottom of a high hill, whose streams united soon form a current sufficient to turn an overshot mill.

In the middle of the principal street is a circular bason, eight or ten feet in diameter, and near five deep: this bason exhibits a very extraordinary appearance; the water is as clear as chrystal, and perfectly resembles a large boiling cauldron, throwing up large bubbles, which burst on the surface with a bubbling hissing noise. From this source, and many others, a great number of the bathing-houses, which are fitted up with the same conveniences

as in the adjoining city, but on a cheaper and less expensive plan, for the accommodation of people of inferior rank, are amply supplied with their mineral water. These sources contain no hepatic air.

The lower order of springs are more distant from Aken, and are all sulphureous; these fountains are very numerous, and some of them within 300 yards of the hot springs in the village, and near to the stream of waste water from the other baths, with which uniting, they form a large fish-pond, and a dam for a mill.

It is no part of my plan to enter into any minute discussion of the difference between the waters of Borset and those of the neighbouring city; though, from the few trials which I made with them with the precipitants, and one or two evaporations



evaporations of the different sorts of fountains at Borset, I have no reason to apprehend any material difference between them, with regard either to the nature or quantities of their several contents. Perhaps these waters may be less stimulant than the waters at Aken, and upon that account may be more suitable in all habits that are disposed to inflammatory diseases: from the want of hepatic air in the upper springs, the baths are less offensive, and of course their use must be much more pleasant and agreeable to those who frequent them.

I shall therefore only make some cursory remarks on these waters, with a short account of a chalybeate spring, called the Spa, within the walls of the city of Aix, and close this article with

some further medicinal reflections on the whole.

The Caroline waters in Bohemia, except in the very small quantity of iron which they are said to contain, resemble in most other respects the upper springs at Borset: the Caroline and Borset waters are both very abundant in their fixed air, they are both devoid of hepatic air, they are both alkaline, and the degrees of heat in the Borset waters must at least be equal to those of the Caroline.—The water in the open basin in the street raised Fahrenheit's thermometer to 140, four degrees higher than the water immediately raised from the bottom of the grand source at the Emperor's bath; and in a little open fountain belonging to the upper set, but situated lower in the town,

town, it was raised to the amazing height of 156 in ten minutes.

It is said, that if a fowl or a swine be dipped in the Caroline water three or four times, all the feathers of the fowl, as well as the bristles of the hog, will come off; and I saw several of the common people dressing calves feet with the water from the fountain in the lower town; several kettles were standing round it with bacon and greens, as well as eggs dressing in them; and in the time that I walked down to view the lower springs, an egg that I had left in the fountain was boiled hard. If a dependance can be put on the relations of the evaporation of the Caroline waters, a quart of them deposited a dram of an alkaline powder, half of which was an alkaline salt; another account says it was the fossil

Y 4

alkali,

alkali, and seventeen grains of the remainder was an absorbent earth : compare this history with the results of the trials on the residuum of the water from the Emperor's bath.—Becher says that iron was contained in the waters of Aix-la-Chappelle, which is not true ; and I believe that he found, by his account of them, no iron in the waters at Carlsbad.

May it not have great future uses, that proper trials should be made of the efficacy of the waters at Borset in particular, as well as at Aix-la-Chappelle, in a variety of calculous disorders ?

Through a mistaken notion of the real composition of the waters of Borset, on enquiry I learned, that the use of them internally is very seldom directed ; for, more through zeal of emolument than true knowledge, a general  
 opinion

opinion is propagated throughout Aken, that the mineral waters of Borset are impregnated with alum ; whereas such people as have drank them for some continued time relate, that they are really more opening and purgative than the waters of Aix. It has been before observed, that alum very rarely makes a part of any mineral water : and I satisfied myself clearly, by real experiment on the spot, that the mineral waters of Borset did not contain the smallest portion of alum, properly so called.

However surprising it may be thought by most people, that two sets of mineral waters, such as are the upper and the lower springs at Borset, which are so nearly situated together, and the springs of each set so numerous, should all so materially differ from those of the other set, that all of them in the  
upper

upper fet should not contain hepatic air, whereas all the springs in the lower one are sulphureous : now, if the supposed means by which the single fountain of Geronstere, near Spa, became impregnated with hepatic air, may be deemed to be rationally accounted for, (the history of which was by accident omitted, while we were treating upon that water, and barely suggested in the account of the sulphureous waters of Aken) a more ample testimony of the probability of such a cause really taking place will be here more abundantly evident, as the springs of sulphureous water are so many in number, and no other or more probable cause of such extensive influence can be found out.

Not far above the lower fet of springs, and between them and the  
cattle

castle of Frankenberg, situated on the top of the eminence, from the bottom of which all these fountains issue, lies a very extensive morass, that was very soft and tender in the middle of August last summer, seemed full of water, and which I had no reason to doubt penetrated deep into the earth, and which was covered over with such vegetables as generally grow in such kinds of soil.

I have before noticed a ferrugineous spring, which was situated within the walls of the city of Aix-la-Chappelle, and which, on visiting it, I found to be a gaseous one : it is called the Spa, lying near that additional part of the town called the Comberstadt, and which, on a slight examination, I had reason to suspect contained a small portion of vitriolic acid.—And here, in a medical view, it may not be improper to

to make some observations on vitriolic waters in general.

All mineral waters, hot as well as cold, that possess any great efficacious powers, must contain greater portions of aerial acid than common water does : all other ingredients, of whatever kind they may be, are heavy and inert, without the aid of this elastic vapour ; and indeed their greatest excellence is entirely owing to the quantity with which they are impregnated of this active and subtle fluid : for all cold mineral waters, on exposure to the open air, will soon part with their aerial acid, hot ones much sooner. Though the aerial acid gives to all waters their greatest efficacy, yet the use of mineral waters is not solely confined to this acid ; Seltzer and Pyrmont waters are both highly gaseous, yet



yet they both possess groffer saline bodies, and to these the aerial acid gives their active and penetrating powers; as to the chrystallized mineral alkali in the Seltzer, as well as it aerates the lime and magnesia; and in the Pyrmont, to the vitriolated lime, magnesia, and salited mineral alkali, as well as it aerates the lime, magnesia, and iron. Cold mineral waters may be divided also into such as contain iron in them, and others that are totally destitute of iron: the ferrugineous are more frequent than any other kind of waters, and many of these contain the iron, either totally or in part only dissolved by the vitriolic acid; and the knowledge of this is of great importance to the physician in directing the use of them. There was a time when vitriolic acid was deemed by them all

the only solvent of iron ; whereas it is well known at present, that such vitriolic waters are very rare ; and happy it is that this is the case, for though, when slightly impregnated, these waters may have their use, yet they, for the most part, are improper, and frequently injurious to the patient. As there is plenty of chalybeate springs, the best ought to be selected : whenever the iron is totally dissolved by aerial acid, the best of the kind will be formed ; and such waters will ever be most efficacious, when they are directed with judgment. There is also a third class of ferrugineous waters, in which the iron is dissolved mostly by aerial acid, and by a small portion of vitriolic acid. Such waters, though not equal to those in which the aerial acid is the only solvent of the iron,

yet

yet may be taken with advantage, when better cannot be readily obtained.

Hot aerated or hepatifated waters may be easily imitated; and, if the aerated hot water only is required, aerate distilled water in the common manner, and suspend the vessel containing it (which may be so formed as to resemble Papin's digester) in a *balneum mariæ*; which, when gradually heated to any degree of heat that may be required, will readily communicate the necessary degree of heat to the inclosed vessel.

Hepatic air may be communicated to distilled water, by putting some powdered *hepar sulphuris*, prepared by melting sulphur and pot-ashes in a crucible, in the room of the chalk that was employed to aerate the preceding  
water;

water; and proceed, as in the other processes, as well to hepatifate as afterwards to heat the water to whatever degree may be required: and in the same manner large quantities of water may be aerated or hepatifated, to form baths of them, by means of a long flexible tube, communicating with the proper substances prepared and mixed together, and the other end introduced into the bottom of the bathing tub; and may be so conducted as not to affect respiration, while the patient is sitting in it.

Real mineral sulphur is more readily precipitated from the artificial waters, by the proper mineral acids, than when found in mineral waters in the form of an hepatic air, and communicated through such a variety of natural processes.

## T H E

MINERAL WATERS, and BOUE BATHS,

O F

S T. A M A N D,

IN FRENCH FLANDERS.

**T**HE real existence of bituminous substances in any mineral water, is rejected by some of the best modern chemists, for reasons, incompatible with their own ideas of the modes of union between real sulphur and water: they are immiscible in water; so are all genuine sulphurs: should an alkaline substance intervene, they are capable of being united; the same is applicable to bitumens: petroleums, agitated with

**Z**                      distilled

distilled water, separate again upon standing; so will any genuine sulphureous body.

Yet they say that the water, with which the bituminous substances are agitated, still retains, after the most careful filtration, a strong bituminous smell; all sulphureous bodies, agitated with distilled water, will leave an hepatic air issuing from the water, till evaporation takes place: If an hepatic air remains for a time, why should we wonder if a more distinguishable aura of bitumens should also remain in it, however temporary it may be?

And why is not such an aura, which is equally permanent and elastic with hepatic air, to be styled a bituminous air, since the latter may contain as little of the original bitumen as the former will be found, in general experiments, naturally to contain of real sulphur?

The

The bituminous aura has an equal title to be called real asphaltum, as the latter has to be deemed genuine sulphur,

Whatever Lucas has advanced on the real union of fetid oils from putrefaction, or bituminous substances with water, is either so inconsistent with the true principles of chemistry, or so debased with the malignity of personal abuse, and enervated with the debilitating poison of self-sufficiency, that it is hardly worthy the notice of a disinterested inquirer into the simple operations of nature.

About the middle of the way between Tournay and Valenciennes, the town of St. Amand is situated, on the banks of the Escaut or Schelde, about thirty miles from its source in Picardy. On leaving the town of St. Amand,

and passing by a gentle descent, near two English miles, you arrive at the mineral fountains distinguished by the name of St. Amand; they lie about half a mile distant from the Escaut, and near forty feet below the bed of the river.

All the country about St. Amand abounds with pit-coal, the chief article of consumption for fuel, and called by the French Charbon de la Terre. On approaching the fountains, you become soon sensible of the same kind of smell as you perceive when near to any sulphureous waters, yet something different in its smell arises from these; and, when very near to them, it becomes still more disagreeable than the vapour from the generality of this class of mineral waters: if any distinction is necessary to be  
made



made in the smell of such hepatic airs, I should be induced to style this particular one an asphaltic air.

Genuine sulphur presents to us one of the most simple combinations, consisting only of two principles, an acid, namely, saturated with phlogiston ; whereas, in the opinion of Bergman, the composition of petroleum, under that name comprehending all this class of phlogisticated bodies, is more intricate ; imagining that a small portion of water, by the means of the acid, is combined with the inflammable principle : all the species of amber more evidently discover their origin to be derived from the vegetable kingdom ; for besides their proper acid and oil, vinegar is evidently discovered in them by distillation, while the earthy residuum may be considered as their matrix.

Within a spacious building (adorned without by a handsome inscription, laying claim to the high antiquity of these mineral waters, from the time when the Roman legions harrassed these countries, and made use of these baths for the relief of their disabled soldiers) and in a large room belonging to the edifice, are placed two fountains, inclosed in two distinct areas, six or seven feet below the floor of the room, one called Bouillon, or Bouillant, The Boiling Fountain; to which distinction it has no real title; and the name may have been given to it in compliment to a great French commander with that title, for there has been a military hospital established at these fountains for more than a century past. The other is called The Fountain of Arras, or L'Eveque d'Arras.

Both

Both these fountains resemble in appearance some of those at Aix-la-Chapelle, as well in their brilliancy as in throwing up great quantities of their air, although in an inferior degree; as they are inferior also to them in the degrees of heat, for in neither of them was the mercury in Fahrenheit's thermometer raised above 75, when in the open air it stood rather below 50 degrees. Neither did the water with the precipitants discover the least traces of iron being dissolved in them; although it might be so subtilely diffused as not to act with precipitants; for on a subsequent analysis of the boue, iron was discovered in it; and I had not time to try, by evaporating different portions of the water, whether then any changes would be wrought in their appearance.

But the most singular circumstance attending the waters of St. Amand is, that in a slight large building of wood, erected within a small distance of the fountains, and in a form resembling a green-house, the whole front to the south being made of glass frames irregularly put together, are contained more than a hundred boue baths ; part of which are reserved for the use of the company who may visit these springs ; another part are appropriated to the French soldiers, who are sent to the military hospital here, erected at the expence of the King of France, where these unfortunate men, who are either wounded at land or sea, or otherwise disabled from the hardships attending a military life, are regularly sent, and maintained at the public expence during a course of these waters and baths.

The

The remaining baths are kept distinct for the use of the poor distressed sick and lame inhabitants of the adjacent country.

Each bath is of an oblong shape, and formed and separated from each other by wooden frames, rather more than five feet long, and about three wide; the depth of the boue in the baths could not readily be ascertained, as will more evidently appear hereafter: as to the consistence of it, they are all more or less liquid, yet the boue in all of them is in so firm a state, that no invalid can be forced down into them, without first digging out part of the boue, which is all of a dark blackish colour.

I before said, that the depth of the boue could not readily be ascertained in the baths: for in order, if possible,

to

to obtain a knowledge of the real depths of the fountains, I procured out of the adjoining woods a staff or pole 28 feet long ; on putting it separately into each of the fountains, I perceived in both of them, about 6 or 7 feet below the surface, the boue, first in a very loose texture ; the consistence grew firmer, as I pushed the staff lower down, but it was frequently interrupted by some solid bodies, perhaps large stones ; in time I readily pressed the whole length of it to the level of the water in both fountains ; but I cannot pretend to say how much deeper the boue might be, as I could not any way procure a rod of sufficient length to make more effectual trials.

The boue or mud in the baths retains the same sulphureous or asphaltic smell, but by its exposure in so large  
and

and open<sup>d</sup> a building, it is deprived of great part of the heat which it must have had in the fountain; yet, when the thermometer was put more than a foot deep into the boue, it raised it to near 63 degrees, at a time that in the open air it did not rise higher than 47, it being early in the morning, rather cold, on the 15th of September, and before the sun was up.

The method that at present prevails in the use of these baths, is to bury the lower part of the body of the diseased person in them, and up to the arm-pits if the disease is seated in the upper part of the spine, or to immerse a part only, or any of the limbs affected; and the patient is to remain in it, either in an erect posture, or resting on the surface of the boue, with blankets or a sheet interposed, for some hours, as the case  
may

may require, and afterwards to be carried to a hot bath, to be cleansed from this black mud that sticks fast to the parts that have been immersed in it.

When conversing with the worthy Dr. Harrington, on a visit I lately made to Bath, concerning these subjects, he informed me that his uncle, who practised physick at Bath, many years before my ingenious friend came there, was used to relate to him, that when he first came to Bath, it was customary to make use of the boue, collected at the bottom of their baths, as an external application, and to keep it, if possible, in the same degree of heat as when it was first taken from the bath : and my learned friend Dr. Marcard, of Hanover, who has lately published a very sensible treatise on the Pyrmont waters, tells me, that it still continues to be customary,



mary, at Pyrmont, to make use of the boue collected in the baths there, as an external application in a variety of cases.

Besides the baths formed in the boue, commodious baths are here also constructed to receive the mineral waters raised up from the fountains below; and the degree of heat is now, and might be readily, by art, still further and more considerably increased: and although there are some pumps erected for the douche, and some attempts made to construct proper vapour baths, yet the accommodations of the place might still be rendered much more convenient and efficacious, and the salutary effects of both the water and boue baths might be still greatly improved.

One most excellent custom, had it  
been

been faithfully executed, has formerly prevailed at these baths, and still prevails, in some degree, though the practice gradually diminishes (yet it is better kept up, I believe, in the military hospital) which is, to have a regular register kept of the cases sent to St. Amand; in which was entered an account of the symptoms and situation of the patients when they first arrived; and an account also registered in the book, from the physician who recommended them there; to which was afterwards annexed an account of the benefits (not always perhaps strictly true) that each patient had received during his course of these waters and baths; and this last account of the cure was formerly signed by the patients themselves: but if every degree of credit is to be paid to some of the accounts that are entered

on

on the books, and from thence given to the public by a variety of authors, who have wrote upon the mineral waters of St. Amand, such extraordinary cures have been effected by them, as would exceed the belief of the most credulous men.

All the writers, who, from motives of interest, or with more honourable views, have given to the public their observations on the effects of that class of mineral waters which are called sulphureous, are very copious in their praises of them in venereal disorders; whether these pretences, supposing them to be real, are founded on their efficacy in the relief of such disorders as are the consequences of an improper use of mercury, or on any specific effects they may have on the peculiar virus of that disorder, cannot admit of a doubt by  
 † sensible

fenfible men ; yet the claims of ftill more extraordinary virtues, in the relief of that difeafe, have been advanced and maintained with the greateft zeal by many authors, in behalf of the waters and baths of St. Amand ; infomuch that fome of them have even expreffed a doubt, whether they did not contain fomething mercurial in their compofition.

It has been before obferved, that all the country about St. Amand abounds with mines of foffil coal, and that it makes the chief article of their fuel ; every inquisitive perfon, who has lived for any length of time in a country abounding with coal mines, and has vifited them, and inquired into the nature of their component parts, will have reafon to be of opinion, that a great part of their compofition was originally

originally in a vegetable state; and might be led to suppose, that in some violent commotions of the earth, in very remote periods of the existence of this terraqueous globe, deep beds of peat, together with the trees and other vegetable productions growing on its surface, might be buried in some places very deep below it, and there combined with bituminous substances that were in a liquid form; from this state of them, in the combination of these bodies together many ages past, the superior parts of the strata of fossil coal would contain most of this lighter part of the composition, which in all coal mines is called the kennel-coal; and the quantity of the bituminous parts growing less and less downwards, till towards the bottom of the strata, stony and other heavier bodies

are are

are combined with the other bodies, this part of the mine being the least valuable as an article of fuel.

I once found, in the middle part of a stratum of coal 14 yards thick, a considerable branch of an oak-tree, divested of its bark, but in all other respects a piece of unconverted wood, and to all appearance as firm and undecayed as it was when it was originally deposited and lodged in the center of so large a mass.

The two fountains of mineral waters at St. Amand, though so near to each other in situation, appear different in the quantity of their component parts: they are, however, similar in the degrees of heat, neither of them raising the thermometer above 75 degrees; yet the Bouillon is less abundant in its aerial gas, as well

well as in its peculiar air, and on evaporation, the same quantity of its water yielded a few grains less of solid contents than did the water of L'Eveque d'Arras.

The saturated tincture of galls, and the phlogisticated alkali, as has been before observed, gave no evident testimony of any iron being contained in these waters ; though there was great reason, from other appearances on the spot, to have expected some marks of it with these precipitants. It is not uncommon, when the solution is highly attenuated, and the quantity very small, that the iron will not appear with the precipitants till the water is half evaporated ; and sometimes the evaporation must be still further increased, before the tests will give evident signs of iron in the water.

Half an ounce of fresh fyrup of violets, mixed with two ounces of the water, from both the fountains, struck a faint green colour : yet the salited terra ponderosa precipitated a small quantity of a spathum ponderosum, which was an evident proof of some portion of vitriolic acid being combined with these waters.

The nitrated mercury, prepared without heat, precipitated a greyish powder, which soon grew of a darker colour; and the precipitate with the acetated lead was still of a darker colour. Nitrated silver shewed signs of a small quantity of a marine acid also in these waters.

With the solution of soap, the mixture was not equable or uniform, but shewed few signs of a real decomposition taking place.

The



The concentrated acids occasioned a small ebullition, and the acid of sugar threw down a small portion of lime.

The tincture of turnsole became of a faint red, but the concentrated nitrous acid precipitated no sulphur.

Before I proceed to the evaporation of these waters, and the chemical analysis of the residua, it may be necessary to inform my readers, that the difficulties attending the removal of my apparatus for that purpose, in the proper manner I could have wished, from Spa and Aix-la-Chapelle to this place, and the utter impossibility of procuring any conveniences there, or at the neighbouring town of St. Amand, prevented my performing it on the spot, in such manner as I hoped, and may be expected: and therefore, on completing the

A a 3      evaporation

evaporation of these waters, in the same mode as in the other waters, I put the residua in glass bottles closely stopped up; and took with me several pounds of the boue, procured at least a foot below the surface, packed up in a proper vessel and closely covered up; having contented myself with such trials as I could conveniently make at the baths, and deferring a more minute examination of them till I was in possession of more correct means of doing it.

On putting small quantities of the boue on different pieces of iron, heated in different degrees, it discharged at first only watery vapours, but the vapour soon became of a sulphureous or asphaltic smell, emitted a blueish and sometimes a reddish flame, till it was nearly all consumed, and a few  
ashes

ashes only from the earths remained on the pieces of iron.

As I had taken several parcels of the boue with me, at the first convenient place that I could procure a commodious apparatus, which was Paris, I exposed one parcel of it to distillation in a reverberatory furnace; after the watery parts were exhaled, I put a receiver to the retort, and having properly luted the vessels, I directed the fire to be raised to a strong degree, and continued it for some time, when I procured half an ounce or more of a liquid of a deep red colour, which was filtrated through paper barely moistened with pure water; and this liquid evidently appeared to the taste and smell to contain a volatile alkali; it effervesced strongly with a moderate vitriolic acid, sensibly so with distilled

vinegar, A a 4

vinegar, and but very little with the marine acid.

On evaporating 70.50 cubic inches of these waters at St. Amand's baths, over a very gentle fire, the pellicle did not begin to shew itself so soon as in those of Aix-la-Chappelle, and part of it, when it appeared, seemed to refract some of the prismatic colours; from whence I was more surprized to have found no changes take place with the precipitants appropriated for the discovery of iron in water: when more than half of it was wasted, the dirty whitish pellicle was precipitated to the bottom of the vessel, and a soft, unctuous substance floated on the surface of the water, which gradually disappearing, a dark-coloured matter appeared precipitating in the remainder of the water, till, on compleating the evaporation,

evaporation, a soft black powder remained in the bottom of an earthen glazed vessel; near thirty grains in quantity, exactly resembling in colour and smell the boue in the baths; though the latter was much less sensible than in the boue, and the taste of it was nearly the same, but less pungent on the tongue.

The appearance of this dark-coloured substance in the residuum was the more surprising to me at the time, as I had just been reading an historical and analytical essay, published by Mr. Desmilleville, a physician of fame and character, on the waters and boue of St. Amand; in which he relates, that in the month of May, 1767, he had made, with the assistance of an able chemist, a Mr. Decroix, of Lille, an exact analysis and critical enquiry into the nature

ture and solid contents of both the waters and boue.

On the supposition that these gentlemen had really made a proper evaporation of these waters, for in one of their twenty experiments, they relate, that on the evaporation of six pounds of the water of the fountain of Arras, the strongest and most impregnated with contents of the two (in the course of which they observed the pellicle that was formed on the surface of the water to be unctuous by the touch) and that when it was evaporated to dryness they discovered only 24 grains of a neutral salt, but do not say of what kind; it must appear something extraordinary, that they should not take the least notice of so singular an appearance: and the greatest part of the list of their experiments (an account of which

which Mr. Desmilleville and Mr. Tre-court have published) are employed in shewing the effects of the waters in the discoloration of metallic substances, and other trifling processes, to prove the existence of a real *hepar sulphuris* in these waters, and which in reality they did not, and could not find, by the methods pursued, if any others would have proved more successful; and the discovery of an hepatic gas has been established since that time, and could not be well known to them.

Such an appearance as I have related, (and which confirms the opinion they wished to know, that the boue in the baths is in great part, if not altogether, a real deposit from the waters) would have been of the utmost importance in silencing the unfavourable reports which had been propagated

EDMUND 2 by

by an anonymous author, who had attacked the reputation of the waters of St. Amand in their most sensible part, as deriving all their sulphureous taste and smell from a filthy stinking morass in the middle of a large meadow, and from whence he has said all their putrid vapours were derived; that their fame and character was entirely unmerited; and that the reports propagated of the extraordinary cures effected by these waters were without foundation, notorious falsehoods, and a gross imposition on mankind.

This unknown writer, against whose malicious aspersions Mr. Desmilleville's book was written, and the plan of his analysis primarily undertaken, had asserted that the most scrupulous and exact experiments had never yet discovered an atom of sulphur in these waters: the  
reality



reality of which is very feebly supported by Mr. Desmilleville; and on burning only a part of this residuum on heated iron, the sulphureous vapours and flame which it exhales would have more effectually established the reality of it in the water, than five hundred such experiments as he has related.

Mr. Desmilleville seems to have taken no notice of another circumstance, of great import in his defence of the reputation and character of these fountains and boue, which would have afforded him a mode of accounting for the bituminous and sulphureous substances, and which he could be no stranger to; and given him ample ground from whence he might have obviated all the suspicions of the neighbouring morasses contributing in any degree to the formation of his favourite

vourite fountains and baths; this is the great abundance of pit-coal in all the surrounding country: and had he attempted the analysis of his boue by distillation, he might have learned from Mr. Venel, how far the analysis of it, exposed to a strong fire in a reverberatory furnace, will resemble the analysis of the charbon de terre, by experiment.—Vide his *Treatise sur la Houille*.—And from the register of the Academie Royale des Sciences we are informed, that, from the experiments of Mr. Morand le fils, Mr. Vauconson, Laffone, and Le Roi, November 25, 1769, certify, that the vapours from charbon de terre in burning are bituminous, and not strictly sulphureous, as generally supposed: and this certificate from the Academy of Sciences was obtained to certify, that the usage  
 of

of fossil coal for culinary purposes, and warming rooms, was not attended with any injurious consequences to the health of mankind, where the grates and flues from the chimneys are properly conducted.

We have before seen, in the waters of Spa, that under evaporation, as well as by standing in the open air for any length of time, as soon as the prismatic colours disappeared in the pellicle, it broke into pieces and subsided; that the waters then lost all their lively and brisk taste, and would shew no changes or alterations with the precipitants; that the volatility of the hepatic gas, either in the open air, or under small degrees of heat, soon deprived the waters of Aix-la-Chappelle of their smart pungent taste, as well as of their disagreeable odour and flavour; and

and that the residua of these last waters appeared of a white shining colour, in no shape of a dark brown and even black colour, like the residua of those at St. Amand.—It must reasonably be expected, (for want of the whole of our apparatus to render it compleat, in order to form an accurate analysis of the boue and the residua on the spot) that however carefully the boue might be packed, or the residua preserved in bottles closely stopped, the volatile parts of them, such as the asphaltic and hepatic airs, would in part, if not altogether escape, in being carried six or seven hundred miles, through Paris and back to London, and kept there some months before proper leisure could be found, and every other necessary provided to examine into them here. And

that

that this was really the case, the subsequent experiments evidently evince. From this decomposition of the substances, vain and uncertain must be every attempt to estimate and ascertain with accuracy the proportional quantities of the different substances found in both the boue and the residua; and therefore, to avoid any mistake and every wrong information in this part of the analysis, no table is formed of the quantities of the different component parts.

When all these several substances deposited from the waters were treated with a dilute vitriolic acid, a considerable effervescence took place, and much fixed air was disengaged.—On boiling different quantities of the boue with the fixed vegetable alkali, no ap-

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pearance of a hepar was to be traced on an examination of the alkali.

No sulphur was sublimed from the boue when heated with a gentle heat.

When put on hot irons, it gave no blue flame, nor exhaled any sulphureous vapour.

The nitrous acid separated no sulphur from the mass.

When acids, particularly the marine, are poured in large quantities on the boue, it exhales an hepatic vapour.

Eight parts of distilled water being boiled for some time with one of the boue, and then filtrated, gave the following appearances on examination :

A quantity of lime-water added to the distilled water, after boiling with the boue, produced no precipitation, and effected no apparent change.

No

No change appeared from salited lime.

Nitrated silver, added drop by drop, produced no white curdly precipitate.

Nor was that effect produced on the addition of a solution of mercury made without heat in the nitrous acid.

The acid of sugar gave an immediate appearance of white dense striæ, when the smallest portion was added; on a sufficient quantity being employed, a copious precipitate of saccharated lime was, after some time, procured.

Salited terra ponderosa gave a copious precipitate of baro-selenite.

On evaporating the water, no saline pellicles, or tendency to form regular crystals, appeared; but a white powder was thrown down, which was found to be gypsum.

A larger quantity of water took up

the whole of the gypsum belonging to the mud that was examined.

Another part of the boue, on which a proper quantity of water had been boiled, was exposed to the action of distilled vinegar, as long as the acid would take up any thing.

The distilled vinegar, thus charged, gave the following appearances with the precipitants :

The tincture of galls threw down a considerable blackish brown sediment.

The Prussian alkali gave a copious precipitation of Prussian blue.

Saccharated lime was thrown down in abundance on the addition of the acid of sugar.

Aerated fixed vegetable alkali threw down a white precipitate ; which with vitriolic acid formed a white and difficultly soluble powder, which was gypsum ;



sum; and a bitter soluble salt, which appeared to be a magnesia vitriolated, or Epsom salt.

Marine acid, digested with the remainder, after the operation of the distilled water and vinegar, left an insoluble residuum, which was siliceous, and was found also to have taken up argillaceous earth.

The gross component parts being thus detected, the examination was not carried any farther.

By the preceding trials and experiments, the following principles manifestly appeared to be contained, though, for reasons before given, the proportional quantities of each are not attempted to be strictly ascertained in the boue and residua of these waters.

Aerated lime.

Aerated magnesia.

B b 3

Aerated

Aerated iron.

Calx vitriolata, or felenite.

Argillaceous and siliceous earths,

as they may be found in the water.

THIS is one instance of

THE aerated magnesia occurring again in these waters, and having before been found in so large a proportion in the Pouhon water at Spa, it may not be improper, before the close of these examinations, to make a few cursory observations on magnesian earths, in order the better to understand the nature of them, as well as to clear up the confusion that appears in some of the best writers on mineral waters in general, through their want of precision in distinguishing the different absorbent earths.

*Lifer, Shert, Ratty, and many other*  
more

more modern systematic authors, talk of a calcarious Glauber's salt existing in many mineral waters ; with as much propriety as they might call selenite a gypseous Glauber's salt.

And this is one instance of the number of imaginary different substances that have been introduced into the analysis of mineral waters, by new combinations, merely through the impropriety of the terms by which they are denominated, and making such a variety of absurd distinctions where the processes of nature, if properly attended to and understood, will appear the most simple.

The general effects of magnesia, when aerated, have been already attended to in the Introduction ; and most of the above writers having no other knowledge of this earth than its

effervescence with acids, it is no wonder that they deemed it to be a calcarious one, and thought no other criterions necessary to distinguish it from lime. Hoffman had informed them, that crabs-eyes, prepared oyster and egg shells, saturated with the vitriolic acid, gave out a substance that was almost devoid of taste; whereas the magnesia earth, united with the same acid, yielded a bitter purging salt, such as exists in Epsom water.

Dr. Black, and Margraaff, have demonstrated, that the nature of magnesian earths holds forth constant and distinct properties, by which they may be distinguished from lime and common calcarious bodies.

The foregoing authors have also formed another class of mineral waters, and which they suppose to contain a calca-

calcarious Glauber's salt, united with a portion of sea salt; and inform us also, that this combined salt will not readily chrySTALLIZE, unless under sudden changes from great degrees of heat to equal degrees of cold; and that it becomes deliquescent in the common spherical air: whereas such combinations arise from salited magnesia, or the magnesian earth combined with the marine acid; and such an union constitutes a great portion of the solid contents of sea-water, and forms what is commonly called the bittern in sea-water.

Magnesian earth is a distinct substance from lime, terra ponderosa, argillaceous and siliceous earths, commonly called clay, and flint: should all these different earths be reduced into the finest powder, and  
rubbed

rubbed together with distilled water, they will not afterwards be separable from one another but by their proper solvents; but he would depart greatly from truth, who should from thence deny that magnesia, or any of the other earths, dissolved or suspended in the water, did not really and distinctly exist in it; and from thence conclude that the different varieties of them were produced by the different saline bodies with which they may be united. This earth exists in Spa, Pyrmont, and Seltzer water, in the very same state as we have it from the shops, and generally prepared by precipitation with an alkali from Epsom salts, and destitute of every acid except the aerial one.

Marine salt is formed by the union of the marine acid with the mineral  
fossil

fossil alkali, called natron also; but natron, combined with the vitriolic acid, makes Glauber's salt; and this last acid, by its union with clay or argillaceous earth, makes alum; the same combined with lime, or calcarious earth, forms selenite. The magnesian earth, lastly, combined with the vitriolic acid, forms the bitter purging salt called Epsom salt; and which exists also in the same form in Seidlitz, Seidschutz, Jessop, and many other waters.

It were much to be wished, that, in all our inquiries after physical knowledge, and the investigation of truth, when deep researches into the nature of the component parts, and well-conducted experiments, have repeatedly ascertained the properties and distinguishing characteristics of any  
natural

natural combinations, the application of any other loose and vague terms, to such complex ideas, may be avoided as much as possible.

The generation and reciprocal transformations of bodies, are inquiries of so subtle and intricate a nature, that nothing certain should be affirmed of the simple parts, by bare similitude only, or a few unconnected experiments upon parts only of the compound: the firm agreement of both analysis and synthesis are absolutely necessary finally to establish the precise ideas of the component parts, as well as of their mode of union; and when once solidly fixed, the application of other terms, through the abuse of words, expressive of any difference in their essential properties, would be destructive of  
of



of its excellence, as well as put an end to all certainty in natural knowledge.

There are many different ways of preparing magnesia; the best and purest is procured by precipitation from Epsom salt, with a large quantity of alkali: the last lixivium of nitre and of common salt, and which will not crystallise, contain magnesia dissolved in nitrous or marine acid; and the magnesia may be collected from them by precipitation, evaporation to dryness, and a subsequent calcination: but the magnesia that is thus obtained by calcination is not equal to that which is prepared by precipitation from Epsom salt; the former, if obtained from the lixivium of nitre, is adulterated with lime; and the common salt will al-

ways

ways leave some marine acid, not to be separated from the magnesia; the force of the fire also will dissipate some of the fixed parts of the magnesia, and therefore leave a greater proportional part of the marine acid. When magnesia is prepared from Epsom salt by precipitation, it may be rendered still purer by calcination, to free it from water and aerial acid; uncalcined, it occasions in some habits uneasy sensations in the first passages, by giving out its aerial acid; and calcination increases its purgative effects. Magnesia forms with the acids the same middle salts; it does not grow sensibly warm with water, nor dissolve in it, like lime; and, from all the experiments hitherto made upon it, it appears to be a genuine pure earth.

Its

Its medicinal powers are too well known to require any attention here ; and it is also sufficiently understood, that, as a purgative, it is uncertain in its effects, from its union with acids.

## MEDICAL REFLECTIONS.

**A**N experienced physician may, from the foregoing examination, imperfect as it is, of these waters and baths, be induced to think (on a consideration of the form of these boues, and the composition of the materials, actuated with asphaltic and sulphureous airs, when they are impregnated with proper degrees of heat) that a useful application, in a variety of shapes, as well as a good internal medicine, is held forth in them, in a variety of diseases, as well as external corporeal affections, from wounds, accidents, and contusions, as through debility and contractions of the limbs ; and that it is of high im-  
port.

port to the public, as well as to every person who may be interested in the reputation and success of the boue baths in particular, of St. Amand; especially the latter, to attend to every possible improvement, for a more elegant as well as a more convenient and efficacious mode of their application, if they wish to improve their property, and maintain the fame and credit of their baths.

Though I do not profess to believe all the marvellous relations of their extraordinary efficacy, in a variety of cases that are here recorded, and circulated by various authors that have written upon them; yet I am so far an advocate in their support, as to think that such cures may be here sometimes effected, by a variety in the modes of their application, when ju-

diciously directed, and the many methods of using both the waters and baths have obtained all the improvements they are really capable of acquiring, as could not be accomplished, if at all, in so speedy and compleat a manner, by any other of the waters and baths at present known in these parts of the world.

The general state of medicine, as a science, till towards the middle of the last century, was founded on the principles of the system originally taught by Galen: and though Paracelsus, and other romantic authors, had introduced many chemical preparations into medical practice, yet the system itself still continued to be supported and maintained, by referring all the different appearances, both of health and disease, to the state of the fluids only.

The

The discovery of the circulation of the blood, happening about that time, drew the attention of the more learned professors to the consideration of an organic system existing in all animal bodies; this knowledge led them to the application of mechanics, in the explanation of many parts of the animal œconomy; but many defects arose from their being little able to carry this branch of natural philosophy to any great extent, or explain all the parts of it in a satisfactory manner: and though chemistry began at this time, or very soon afterwards, to promise greater resources in the explanation of many phænomena in the history of diseases, yet the humoral pathology still continued to compose the great bulk of every system of physic.

It had been observed, from very ancient times, that every animal body contained in itself a power or ability of resisting injuries that were offered to it from without, by which also it could frequently relieve itself, and remove diseases that were introduced into it ; this was attributed to some agent in the system of the animal body, and which was called nature ; and which, under the term *vis conservatrix*, or *medicatrix*, has maintained its ground till the present times.

Stahl placed this power in the rational soul, which acted independently of the body, and, from its knowledge of the offending causes, would excite certain motions in the animal fibres, to obviate their ill effects, and by these means get rid of all the consequences from the injury that had been offered to the system.

Hoffman



Hoffman changed the medico-organic power of Stahl, seated in the soul, into a medico-mechanical power of nature: both which systems, in the hands of all the learned men who embraced these doctrines, produced a very feeble and defective mode of practice, leaving more to be hoped for from the powers of nature than the events of the diseases could justify; which superseded all the attempts of art, and led to an absolute rejection of some of the most powerful remedies, such as are opium and the Peruvian bark; a system which ought never to be generally admitted, but where the inability of art to give relief is manifestly striking, and has been confirmed by reiterated, though vain, attempts of cure.

It must however be confessed, that,

from various parts of his works, it manifestly appears, that Hoffman himself was not perfectly satisfied with the doctrine : he was ever eager to adopt new systems, through the warmth of a sanguine temperament ; yet, as he had a clear head, and a good heart, he soon perceived great defects in it ; and, by new modifications of the opinions of his predecessors, as well as his own doctrines, he absolutely gave rise to the great improvements that have been since made in the more successful methods of practice, by the introduction of spasm, or simple atony ; and brought forward a new pathology, in which the symptoms of many diseases are deduced from disturbed motions of the solids, more evidently than they can be from any vitiated disposition of the fluids ; and which he refers, in  
many

many parts of his writings, to preternatural affections of the nerves and the nervous system.

Infinite are the obligations which physicians owe to Hoffman, for leading them into this train of investigation; and there is still great reason to believe, that there remains much room to carry our inquiries still farther than they have already been, before we shall attain to the most perfect mode of practice: the subject is attended with infinite difficulties, for the laws of the nervous system, in many circumstances of the animal œconomy, are by no means hitherto ascertained: we must not be surprized that Hoffman, blinded as he still was with the absurdities of the humoral pathology, made no further progress in a subject almost inexplicable, when

Boerhaave, a man of greater abilities, and universal erudition, left the system loaded with great imperfections and deficiencies, insomuch that a new one, and a better, if possible, still appears necessary.

It will not be required on this occasion to point out the defects of Boerhaave's system, though justly founded on the rigidity or laxity of the simple solids primarily ; but the danger of his system seems to arise from such mistakes as may lead us into erroneous practice. His inattention to the changes that may happen in the living solid, changes that seldom take place in the simple fibre, considered only with regard to its original laxity or rigidity, may be one and a great cause of frequent errors. His supposition of an acrimony or lentor existing in the state and condition

dition of the animal fluids, may be another source of great mistake; and this opinion seems evidently a part of an hypothetical humoral pathology.—

Another misfortune, attending every modification of the humoral system, arises from the diversion it occasions of our attention from the various motions existing in the animal system, upon which the phænomena of diseases most certainly and most generally depend: and Boerhaave's acid and alkaline acrimony of the fluids is not only hypothetical and unsupported by fact, but is inconsistent with other general doctrines he has advanced, and justly, of the general nature of the animal fluids.

The use that is intended to be made of the preceding short narrative of the general systems of medicine, as a science,

ence, prevailing in the world in different ages—and which have governed and directed the practice of all the physicians who lived in those different times—is the application of these different systems to the medicinal uses of different mineral waters, and to the different views that physicians must have had, under the influence of such different doctrines, in selecting the choice of the different mineral waters, and recommending any particular ones to their patients; which application is intended to be made exclusive of the facts collected from experience, and delivered to the world in the different histories and publications of cases which have received benefit from the use of these several different mineral waters.

The disciples of Galen, and the patrons of plethora and cacochymy of  
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the fluids being the only causes of disease, must direct their attention principally to mineral waters abounding with absorbent and alterative earths, joined to purgative salts: and the disciples and successors of Stahl, if any still remain in Germany, seem to have been actuated by such motives, chiefly, in directing their patients to take all mineral waters in excessive large quantities; hence, whenever a German is sent to any mineral water, of whatever nature it may be, he will be sure to drink three times the quantity that the people from any other country do.

The admirers of Hoffman, who, under every modification of his doctrines, still continued a humoral pathologist, will put great confidence in the alterative principles of every mineral water: while others, who are struck  
with

with his doctrines of spasm, will search for sedative qualities in the waters, in which they can place the greatest degrees of confidence.

The school of Boerhaave will search for cold and warm baths to relieve the diseases arising from the lax or rigid fibres of their patients; and happy would it be for them if their physicians were equally instructed in those changes which may more abundantly affect the living fibre: it is equally to be hoped, that practical experience has taught them to look upon acid or alkaline acrimony as imaginary causes of different classes of diseases.—And the disciples of every other school of medicine, in these more enlightened and better instructed times, will diligently attend to the effects of mineral waters on the different animal motions, without speculating



culating on those fanciful hypotheses, which have ever been found prejudicial to the cause of real science in general, but, when applied to the study of medicine in particular, can hardly fail of being attended with consequences still more serious and full of danger.

The mysterious parts of medicine, when considered as a science, if there is any mystery in the art of healing, (and the less there is the better) independent of real knowledge and science, aided and assisted by experience, and a faithful and constant attention to the rise and progress of disease—have been so long involved, and through so many ages, under thick clouds and darkness, from a supposed variety in the different kinds of acrimony existing in the humours and fluids; and the art itself

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has

has been so long encumbered with a confused farrago of useless compositions, called medicines, calculated, as is supposed, to correct such imaginary sharpnesses in the blood and humours; that a true physician will think it his duty attentively to consider what are the real powers of nature, in the relief of the melancholy list of diseases to which the human frame is either liable, or exposed, from intemperance and impropriety of conduct; and he will soon find, when put into a proper track to investigate them, that these powers are derived, as well as the diseases themselves, from a very different part of the animal system; and, besides what information he may obtain from the best writers on the *solidum vivum*, and the doctrines of irritability now taught

taught in the best schools of medicine, he will think it the principal part of his profession to understand, and comprehend fully, all the causes and effects of animal motions, as far as the knowledge of them can be obtained by human sagacity.

F I N I S.

## P O S T S C R I P T.

**T**HE Author of these Essays purposes to have them translated into French, under his own inspection, next winter; to which will be added, such further information as he may obtain on a second visit to the same fountains, this present season: and such additions, should any occur worthy of notice, will be printed also in English, next winter, for the accommodation of the purchasers of the present Treatises.

London,  
July 1st, 1788.













